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See Full Page Advt., page 76, Sept. 16.

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See Full Page Advertisement page 74, Sept. 16.

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See half-page Advertisement, page 72, Sept. 2.

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Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

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Full Time Courses in Mechanical, Civil and Electrical Engineering for B.Sc.(Eng.) degrees, University of London or College Diploma commence September 20th.
Fee: £18 per Session. B 952

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Head of Department — A. W. LOVERIDGE, B.Sc. (Eng.), A.R.C.Sc.

The following Courses have been arranged for Engineering Students:—
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These courses are suitable for students preparing for degrees in Engineering or for the examinations of the Engineering Societies.
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JOHN J. JACKSON, B.A.,
Director of Education.
City Hall, Cardiff. S 53

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R. MULLINEUX WALMSLEY, D.Sc.,
Principal. S 25

Inst. C.E., I. Mech. E., B.Sc.,

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TENDERS.

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The Directors are prepared to receive

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No.		Specification Fees.
1.	Chintz, Turbans, &c.	7s. 6d.
2.	Lamps and Fittings	2s. 6d.
3.	Lamp Glasses, &c.	2s. 6d.
4.	Twines, &c.	5s. 0d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Chintz, Turbans, &c.," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 4th October, 1921.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Company's Offices, Secretary.
48, Cophall Avenue, E.C. 2.
London, 21st September, 1921. S 133

CORPORATION OF LOUGHBOROUGH.

ELECTRICITY DEPARTMENT.

The Corporation of Loughborough invite

Tenders for the following

EXTENSIONS of their ELECTRICAL UNDERTAKING:—
(a) STEAM RAISING PLANT,
(b) HIGH AND LOW PRESSURE MAINS NETWORKS.

Copies of Specifications, with Form of Tender, General Conditions and Drawings, can be obtained of the undersigned either at 7, Victoria Street, Westminster, S.W. 1, or 11, Mosley Street, Manchester. A deposit of Three Guineas in respect of each Specification is required which will be returned as soon as the Contract is let provided that a *bona fide* tender be submitted and not withdrawn. Duplicate Specifications will be supplied on payment of half a guinea each, which sum is not returnable.
Tenders, enclosed in envelope sealed with wax and clearly endorsed "Tender for Steam-Raising Plant, Loughborough," or "Tender for Mains, Loughborough," must be addressed to the undersigned at 7, Victoria Street, Westminster, S.W. 1.
Tenders for Steam Raising Plant must be delivered not later than Noon Monday, October 31st, 1921, and those for Mains not later than Noon on Monday, October 17th.
C. H. WORDINGHAM, S 91
M.Inst.C.E., M.Inst.E.E.,
Consulting Engineer.

COUNTY BOROUGH OF SOUTHPORT.

FOR SALE BY TENDER, THE SEWAGE PUMPING PLANT AT THE CHATHAM ROAD SEWAGE WORKS, BIRKDALE, SOUTHPORT.

The Southport Corporation invite

Tenders for the above Plant,

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No. 2 Cornish Boilers each 16 ft. long by 5 ft. diameter, with all the mountings and fittings.
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The Contractor will be required to remove the plant from its present position in the buildings at his own risk and cost.
The Corporation does not bind itself to accept the highest or any Tender.
Sealed Tenders, endorsed "PUMPING PLANT, BIRKDALE SEWAGE WORKS," must be made on the official form, which may be obtained from the undersigned, and delivered at the Borough Engineer's Office, Town Hall, Southport, before Ten a.m., on Monday, the 3rd day of October, 1921.
Further particulars may be had from the undersigned.
A. H. JACKSON, A.M.I.C.E.,
Borough Engineer.
Town Hall, Southport.
15th September, 1921 S 90

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders from such

Persons as may be willing to supply:—
25 lbs. RAILS and FISHPLATES.
The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 11th October, 1921, after which time no Tender will be received. S 119

T. RYAN,
Director-General of Stores.

NEW ZEALAND GOVERNMENT.

Tenders are Invited for

the SUPPLY of ELECTRICAL PLANT, as set out hereunder, for the MANGAHAO POWER SCHEME, and should be lodged in writing with the SECRETARY, Public Works Tenders Board, Wellington, New Zealand, not later than noon on Tuesday, 29th November next. Tenders to be endorsed "Mangahao Electric Power Plant."

Section	12	Water Wheels, &c.
,,	13	Generators.
,,	14	3-Unit Exciters.
,,	15	Transformers.
,,	17	110,000 Volt Insulator.
,,	18	Lightning Arrestors.
,,	19	Switchboard Switches and Accessories.

Specifications and Plans are available for inspection at the Office of the HIGH COMMISSIONER FOR NEW ZEALAND, 415, Strand, London, W.C. 2.
The lowest or any Tender not necessarily accepted. S 160

APPOINTMENTS OPEN.

STAFFORDSHIRE EDUCATION COMMITTEE.

COUNTY TECHNICAL COLLEGE, WEDNESBURY.

Applications are Invited for

the POST of ASSISTANT LECTURER IN METALLURGY at the above College. The candidate should have had good works and teaching experience, and a University degree is desirable.
Salary according to the Burnham scale.
Further particulars and forms of application, which should be returned on or before 13th October, 1921, may be obtained from the undersigned on receipt of a stamped addressed envelope.
GRAHAM BALFOUR,
Director of Education.
County Education Offices,
Stafford.
September, 1921. S 105

LOUGHBOROUGH COLLEGE.

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Wanted Instructor in Oxy-

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It is regarded as essential that candidates shall be fully skilled craftsmen, capable of giving practical demonstrations to students.
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Commencing salary £300 per annum.
Applications must be submitted on the prescribed form, which may be obtained from the PRINCIPAL of the College, to whom they must be returned not later than Wednesday, the 28th September, 1921. S 89

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EAST HAM TECHNICAL COLLEGE: EVENING CLASSES.
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Required, a Teacher for

Manual Training (Metalwork) for the City and Guilds of London Institute examinations on Monday, Tuesday and Wednesday evenings from Seven to 9·30 o'clock.
Preference will be given to candidates who have had experience in teaching. A form of application, together with the conditions of appointment and scale of salaries, may be obtained from the undersigned or from the Principal, Technical College, East Ham, E.6.
(Signed) F. R. THOMPSON,
Secretary.
16th September, 1921.
Education Office,
Town Hall,
East Ham, E.6. S 122

Experienced General Manager

REQUIRED for Works manufacturing various classes of Steel Tubes. Replies treated absolutely confidentially.—Write "G. D.," c/o J. W. Vickers & Co., Ltd., 5, Nicholas Lane, London, E.C. 4. S 94

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REQUIRE the SERVICES of a DISTRICT LOCOMOTIVE SUPERINTENDENT. Should have been trained in a Contractor's Locomotive Works or Railways Works. Age 28–30, preferably unmarried. Starting salary £E.480 per annum, plus a temporary war bonus of £E.120. Candidates should have passed the examination of the A.M.I.C.E. and have had a thorough training in the construction and operation of locomotives. The post is progressive and pensionable.—Apply by letter to the CONSULTING MECHANICAL ENGINEER, Sudan Government Railways and Steamers, 5, Northumberland Avenue, W.C. S 87

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SIR DOUGLAS FOX & PARTNERS,
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QUIRED by a Firm of Contractors engaged on Dam and Irrigation Works in Sudan, fully qualified MECHANICAL ENGINEER, able to take charge of Steam Navvies, Lubecker Excavators and Bucyrus Draglines. Only applications from Candidates with sound mechanical knowledge and accustomed to control men will be considered. Three years' agreement. Rate of pay, £E60 per month (£E1 equals £1 0s. 6d.). Free quarters and free passage out and home on termination of engagement.—Address, stating age and particulars of experience, S 98, Offices of Engineering.

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The man appointed will be expected to see that all machinery throughout the Company's operations is run at the maximum efficiency.
The position demands initiative, energy, and an exceptionally high degree of scientific and technical knowledge, and a wide practical experience.
Address, stating age, full particulars of qualifications and salary required, S 75, Offices of Engineering.

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Engineering Firm in India, MECHANICAL DRAUGHTSMAN, age about 25, single.—Reply, stating age, experience and salary required, Z.W. 598, c/o Deacon's, Leadenhall St., London. S 127

Two Draughtsmen with Good

Experience of Locomotive, Carriage and Wagon Design, REQUIRED by Argentine Railway; age not over 35; Salary, £600–£650 per annum on three years' agreement.—State age and full details of education, training and experience, and send copies (only) of testimonials to BOX "B. R.," c/o Davies & Co., 95, Bishopsgate, E.C. 2. S 126

Leading Draughtsman to Take

CHARGE in small Office in Glasgow, designing Valves for high steam pressures and high superheats, also Valves for general purposes. State age, experience, and salary required.—Address, S 95, Offices of Engineering.

Wanted Two Good Senior

DRAUGHTSMEN with first-class experience in the design of high-class Motor Cars and water-cooled Aero Engines, for firm in London District.—Address, giving particulars of experience and salary required, S 96, Offices of Engineering.

Wanted, by Old-established

Engineering Firm in India, STRUCTURAL DRAUGHTSMAN, age about 25, single.—Reply, stating age, experience and salary required, Z.X. 599, c/o Deacon's, Leadenhall St., London. S 129

Architectural Draughts-

MAN (Junior) REQUIRED with previous Drawing Office experience, knowledge of Building Construction and Surveying and Levelling.
Preference given to Ex-service men.
Write stating age, experience, salary required, and enclosing recent testimonials, together with evidence of Military Service, if any, to THE OFFICER IN CHARGE OF WORKS, Naval Training Establishment, Shotley, near Ipswich. R 991

Works Foreman Wanted for

Gas Compressing Works, must be a practical Mechanical Engineer able to deal tactfully with his men. Permanency to suitable applicant.—Address, S 118, Offices of Engineering.

The Sudan Government Rail-

WAYS REQUIRE the SERVICES of a FOREMAN BOILER MAKER. Age 28–33, preferably unmarried. Should have been trained in a Locomotive Works or Railway Boiler and Repair Shop. He should have a knowledge of marking out and dealing with running repairs. Rate of pay £E.324 per annum, plus a temporary war bonus of £E.120 per annum. The post is progressive and pensionable.—Apply by letter to the CONSULTING MECHANICAL ENGINEER, Sudan Government Railways and Steamers, 5, Northumberland Avenue, W.C. S 88

SITUATIONS WANTED.

Buyer.—The Manager of a

large purchasing department who has had long and very special experience in this line DESIRES to negotiate NEW APPOINTMENT as Buyer or Buyer and Stores supervisor. Services could be available very quickly.—Write, Z.Y. 292, care of Deacon's, Leadenhall Street, London, E.C. 3. S 50

THE ROTARY PIERCING MACHINE FOR STEEL AND COPPER BILLETS.

By C. E. DAVIES, A.M.I.Mech.E.

(*Continued from page* 399.)

(4) *Angle of Torsion for Conical Billets.*—The last section concerns the piercing of truly cylindrical steel bars (of a very homogeneous quality), 80 mm. to 160 mm. diameter, but now rough cast billets, or ingots which are slightly conical, 130 mm. to 450 mm. diameter, 1,000 mm. to 1,200 mm. long, which must be dealt with.

The top end of the ingots is assumed to be 15 mm. smaller in diameter than the bottom end; even this taper is so small as to render removal of the ingot from its mould very difficult, but it is necessary to keep it as small as possible otherwise its influence on the angle of twist becomes appreciable. At the small end of the ingot the angle ϕ will have its least value, while at the large end it may be as much as 2 to 2¼ times as great; there will also be a tendency to form an irregular hole, and in any case a great difference in the resistance of the plug will be noticed.

The length of the billet in contact with the rolls must be ascertained. Assuming that the large end of the ingot enters the rolls first. (See Fig. 10.)

Fig. 10. CONICAL BILLET BETWEEN CONICAL ROLLS. THICK END LEADING.

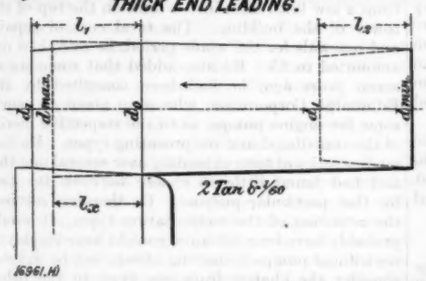
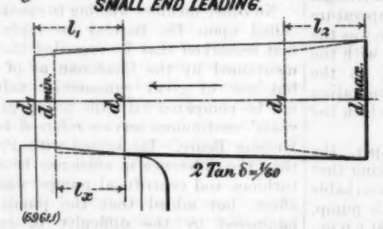


Fig. 11. CONICAL BILLET BETWEEN CONICAL ROLLS. SMALL END LEADING.



Let the small angle which the side of the ingot makes with its axis be called δ, then:

$$d_0 = d_1 + 2\,l_1 \tan\alpha\,;\ \text{also}\ d_0 = d\ \text{max.} - 2\,l_x \tan\delta.$$

Both the conical frustra, with length l_1 and l_x have equal volumes, and taking the given ratio $l_x = 0{\cdot}9\,l_1$, the value of l_x can be exactly determined:

$$l_1 = \frac{d\ \text{max.} - d_1}{2\,(\tan\alpha + 0{\cdot}9\tan\delta)} \quad . \quad . \quad (9)$$

and for the hindermost end of the ingot:

$$l_2 = \frac{d\ \text{min.} - d_1}{2\tan\alpha} \quad . \quad . \quad . \quad (10)$$

The diameter d_1 is taken so that the reduction in diameter for the two ends lies between 0·05 and 0·15 of the diameter in question. From l_1 and d_1, d_0 is next obtained, hence the joint dimensions are known.

Next, consider if the small end of the ingot is first introduced between the rolls (see Fig. 11). By changing the expression previously given,

$$d_0 = d_1 + 2\,l_1 \tan\alpha\,;\ \text{and}\ d_0 = d\ \text{min.} + 2\,l_x \tan\delta.$$

Assuming $l_x = 0{\cdot}9\ l_1$, we have for the thin end of the billet:

$$l_1 = \frac{d\ \text{min.} - d_1}{2\,(\tan\alpha - 0{\cdot}9\tan\delta)} \quad . \quad . \quad (11)$$

and for the thick end:

$$l_2 = \frac{d\ \text{max.} - d_1}{2\tan\alpha} \quad . \quad . \quad . \quad (12)$$

d_1 is again assumed as before, and d_0 estimated accordingly.

Example.—If it is desired to pierce a round conical ingot 450 mm. to 430 mm. diameter, 1,200 mm. long, the greatest roll diameter being D = 550 mm.:

d max. = 450 mm.; d min. = 430 mm.
Tan δ = 10/1200. Tan α = 1/15. d_1 = 400 mm.

Case (1).—Large end first. (Equations (9) and (10)):

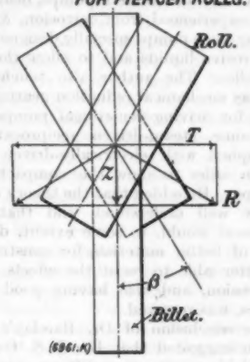
$$l_1 = \frac{450 - 400}{2\left(\frac{1}{15} + 0{\cdot}9\,\frac{1}{120}\right)} = 337{\cdot}4\ \text{mm.}$$

$$l_2 = \frac{430 - 400}{2 \times \frac{1}{15}} = 225\ \text{mm.}$$

$$d_0 = 400 + \left(2 \times 337{\cdot}4 \times \frac{1}{15}\right) = 445\ \text{mm.}$$

Both the values for the torsion angle can now be calculated by equation (8) for tan α = 1/15.

Fig. 12. DIAGRAM OF FORCES FOR PIERCER ROLLS.



At start:

$$\phi_1 = \frac{550\,.\,\frac{45}{400} - 505\,.\,\frac{45}{445}}{550 + 505}\,.\,\frac{360}{0{\cdot}01833}^{\circ} = 200{\cdot}8^{\circ}$$

(These results are corrected from the original.)

At finish:

$$\phi_2 = \frac{550\,.\,\frac{30}{400} - 520\,\frac{30}{430}}{550 + 520}\,.\,\frac{360}{0{\cdot}01833} = 91{\cdot}2^{\circ}$$

(These results are corrected from the original.)

Case (2).—Small end first. (Equations (11) and (12)):

$$l_1 = \frac{430 - 400}{2\left(\frac{1}{15} - 0{\cdot}9\,\frac{1}{120}\right)} = 253{\cdot}8\ \text{mm.}$$

$$l_2 = \frac{450 - 400}{2 \times \frac{1}{15}} = 375\ \text{mm.}$$

$$d_0 = 400 + \left(2 \times 253{\cdot}8 \times \frac{1}{15}\right) = 433{\cdot}8\ \text{mm.}$$

The values for the torsion angle are as follows—

At start:

$$\phi_1 = \frac{550\,\frac{33{\cdot}8}{400} - 516{\cdot}2\,\frac{33{\cdot}8}{433{\cdot}8}}{550 + 516{\cdot}2} \times \frac{360}{0{\cdot}01833} = 115{\cdot}3^{\circ}$$

At finish:

$$\phi_2 = \frac{550\,\frac{50}{400} - 500\,\frac{50}{450}}{550 + 500} \times \frac{360}{0{\cdot}01833} = 246{\cdot}9^{\circ}$$

The figures just given show very clearly the very variable results obtained with a conical ingot, in both cases taken, the difference in behaviour for the two ends is very important, but it is preferable that the large end of the billet enter the rolls first, because the existing flaw or "sponginess" at the top small end of the ingot influences the piercing operation advantageously.

When calculating the tangential velocity and the torsion angle, no allowance has been made for the slip which takes place between the rolls and the work. The transmission of motion from the rolls to the billet can never be perfect, and there will either be a retardation owing to the rubbing friction or an acceleration due to the rolling action. Thus the tangential velocity and consequently that in the direction of the axis of the billet is affected by the friction between the rolls and work. It is therefore necessary to insert coefficients which allow for known conditions, which have so far been omitted.

Fig. 12b.

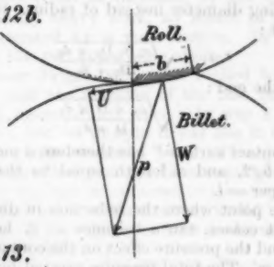


Fig. 13.

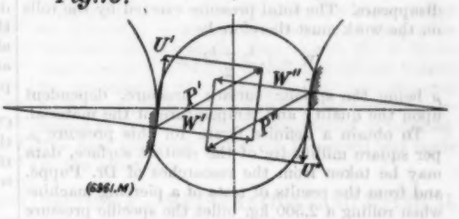
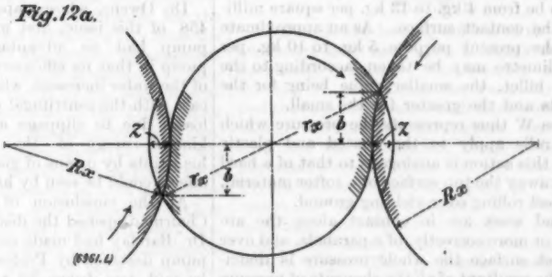


Fig. 12a.



(5) *Power Effects.*—To commence the piercing operation. After the rolls have been set in the best position, the billet must be entered correctly. As soon as the billet is gripped by the rolls, it will be automatically drawn through, at the same time forming a "working surface" between the rolled material and the rolls, which will be referred to briefly as the "contact surface."

Further the friction R, previously referred to, due to the pressure exerted by the rolls on the work, is indicated in Fig. 12, as a force which is perpendicular to the axes of the rolls. This friction with its components T = R cos β, and Z = R sin β acts on the material of the billet.

The force T causes, in conjunction with the roll pressure, a tangential displacement of the outer surface of the billet (which has been brought to a blood-red heat, and is therefore in a plastic condition). The force Z causes a displacement of the "skin" of the billet longitudinally, since the taper of the roll barrel offers a resistance to the forward travel of the work as a whole. At the beginning of the rolling period the resistance of the plug does not exist.

By the combined action of the above forces, the material is displaced in a spiral direction, and at the same time the billet is reduced in diameter. The reduction of the billet "cone" at any cross-section is 2 z (Fig. 12a). The dimensions of the

"contact surface" can be estimated as follows:—The following relation exists:

$$2z : (d_0 - d_1) = Sx : l.$$

Taking S x from equation (2) and if $l = \frac{(d_0 - d_1)}{2 \tan \alpha}$,

$$z = d_x \pi \tan \alpha \tan \beta \quad . \quad . \quad . \quad (13)$$

For any given mill the reduction in thickness per revolution of billet is proportional to its diameter.

From Fig. 12a, the width of the contact surface b, at any given position, may be determined as follows:

$$z = R_z - \sqrt{R_z^2 - b^2} + r_z - \sqrt{r_z^2 - b^2}$$
$$= R_z \times \tfrac{1}{2} \frac{b^2}{R_z^2} + r_z \times \tfrac{1}{2} \frac{b^2}{r_z^2}$$
$$= \tfrac{1}{2} b^2 \left(\frac{1}{R_z} + \frac{1}{r_z}\right)$$
$$b = \sqrt{\frac{2z \times R_z \times r_z}{R_z + r_z}} \quad . \quad . \quad . \quad (14)$$

Inserting diameter instead of radius, we have at the start:

$$b_1 = \sqrt{\frac{z_1 \times D_0 \times d_0}{D_0 + d_1}} \quad . \quad . \quad . \quad (15)$$

and at the end:

$$b_2 = \sqrt{\frac{z_0 \times D \times d_1}{D + d_1}} \quad . \quad . \quad . \quad (16)$$

The "contact surface" has therefore a mean width of $b_1 + b_2/2$, and a length equal to that of the billet taper $= l$.

At the point where the reduction in diameter of the billet ceases, tan α becomes $= 0$, hence also $z = 0$, and the pressure effect on the contact surface disappears. The total pressure exerted by the rolls on the work must therefore be:

$$W = l \cdot \frac{b_1 + b_2}{2} \cdot \rho.$$

ρ being the specific surface pressure, dependent upon the quality and temperature of the material.

To obtain a definite figure for this pressure ρ, per square millimetre of the contact surface, data may be taken from the researches of Dr. Puppé, and from the results of tests of a piercing machine when rolling a 2,500 kg. billet the specific pressure is found to be from 4 kg. to 13 kg. per square millimetre of the contact surface. As an approximate figure for the present purpose 5 kg. to 10 kg. per square millimetre may be taken, according to the size of the billet, the smaller value being for the large billets and the greater for the small.

The force W thus represents the pressure which the hard rolls apply to the heated and plastic material; this action is analogous to that of a hard roll rolling away the top surface of a softer material, or to a wheel rolling over yielding ground.

Rolls and work are in contact along the arc of a circle, or more correctly, of a parabola, and over this contact surface the whole pressure is distributed. The resultant of all the elements of pressure must, if the bearing surface is smooth, pass through the centre point, and has a horizontal component, determined from the equation $U/W = b/2/R_z$ (see Fig. 12b). From which $U = W\left(\frac{b}{2 R_z}\right)$.

Therefore $\frac{b}{2 R_z}$ represents the coefficient of friction between the surfaces in contact. The motive power driving the rolls has to overcome this force U, and also, of course, the journal friction resulting from the rolling pressure.

If the resultants of these forces P′, P″ . . . P5 are drawn in, then the forces P′ and P″ form a couple, which bring about the turning of the work on the axis of its length, while the change in shape of the work takes place sumultaneously (see Fig. 13).

Since the rolls are inclined to one another the forces P′ and P″ do not lie in the plane of the cross-section, but in a third direction so that as Fig. 12 shows, they may be split up into two components Z′ and T′, one in the direction of the axis of revolution of the work and the other at right angles to it.

The sum of the first-named components is represented by Z in Fig. 12, and causes, as explained, the movement of the outer surface of the billet along the axis of its length, if the billet as a whole is held fast by any sort of resistance. (In this case by the taper of the roll barrel.) The sum of the second components, represented by T, acts upon the surface of the material at right angles to the axis of revolution. The forces Z and T together produce the forward spiral movement of the outer surface which is transmitted to the inside of the billet.

(To be continued.)

THE BRITISH ASSOCIATION.
SECTION G.—ENGINEERING.

(Continued from page 409).

CENTRIFUGAL PUMPS.

IN opening the proceedings of Wednesday, the 14th instant, the last day of the Session, the Chairman, Professor Gibson, called on Dr. S. F. Barclay, to read his paper on modern high-speed centrifugal pumps, an abstract of which paper we propose to give in a later issue. The paper, which was illustrated by a large number of lantern slides, traced the development of the centrifugal pump from early times up to the present day, giving characteristic curves of early and modern pumps, dealing with the troubles experienced from corrosion, &c., and also describing some pumps specially designed for dealing with corrosive liquids and to allow the passage of solid bodies. The author also touched on such matters as mechanical reduction gearing and water turbines for driving centrifugal pumps, and illustrated some steam-driven reciprocating pumps photographed with electrically-driven centrifugal pumps in order to show the compactness of the latter type. He added that the theory of the pump was now well understood, and that its future development would, to some extent, depend upon the use of better materials for construction. An alloy better able to resist the effects of abrasion and corrosion, and also having good mechanical properties, was required.

At the conclusion of Dr. Barclay's paper, the Chairman suggested that Dr. J. S. Owens should then read his paper on air lift pumping, and that the two papers should subsequently be discussed together.

EXPERIMENTS ON AIR-LIFT PUMPING.

Dr. Owens, whose paper we reproduce on page 458 of this issue, first mentioned that the air-lift pump had an advantage over the centrifugal pump in that its efficiency rises as the temperature of the water increases, whereas the opposite was the case with the centrifugal pump. He dealt with the losses due to slippage and friction, and to the kinetic energy of the discharge, demonstrating his points by means of glass apparatus in which the effects could be seen by his audience.

At the conclusion of Dr. Owen's paper, the Chairman opened the discussion by remarking that Dr. Barclay had made no mention of a remarkable pump designed by Professor Rateau. This pump, he said, was driven by a turbine at 12,000 r.p.m., and delivered against a head of 800 ft. Its impeller was only 3 in. in diameter, but the efficiency was 55 per cent., which he regarded as a remarkable performance. He also mentioned that the original Reynolds' pump had been working in the laboratory of the University of Manchester for some 37 years, and was still in excellent condition. It was of the four-stage type, ran at 1,500 r.p.m., delivering 16 cub. ft. per minute against a head of 150 ft. Its measured efficiency, he said, was 58 per cent. He also enquired if Dr. Barclay considered the much lower efficiency of single-stage turbine pumps as compared with hydraulic turbines, was due to a dimensional effect; the speaker thought this must be the case. Of Dr. Owens, the speaker enquired whether he had read a recent paper before the Institution of Mechanical Engineers by Mr. W. Purchas on air-lift pumping, and whether he agreed with the displacement theory of the action of the air-lift pump put forward in that paper.

Professor F. C. Lea, the next speaker, said he wished to refer to the comparison of reciprocating, and centrifugal pumps made by Dr. Barclay. It had been stated that the capital cost of a reciprocating pump was five times that of an electrically-driven centrifugal pump of equal capacity, but, in this respect, it must be borne in mind that current had to be provided to drive the latter. He rather thought that when capital cost, running charges and cost of current were all taken into consideration, the reciprocating pump would prove more economical than the centrifugal pump. It had also been stated that the electrically-driven centrifugal sets required little or no attention, and this was probably true if the load were always constant, but was not so in the conditions usually met with in supplying ordinary distribution mains or a number of hydraulic installations. One advantage of the centrifugal pump was that there was little likelihood of hammer action and it was possible to start the pump with the valve on the rising main closed without doing any damage. There was, however, a possibility that the motor would be overloaded in the event of a breakage of the delivery main. On Dr. Owens' paper, the speaker remarked that the air-lift pump had the great advantage, for certain classes of work, that all the moving machinery was kept on the surface. Centrifugal pumps would be very expensive to install in such circumstances, since, owing to the low suction lift obtainable, they would have to be installed below ground. In conclusion, he asked if Dr. Owens could give definite figures as to the relative efficiency of air-lift pumps and centrifugal pumps in long-continued working. The efficiency of the air-lift pump was the lower of the two, and this might counteract the effect of the saving resulting from having the machinery on the surface.

Professor T. Hudson Beare, who followed, remarked that he had had a centrifugal pump running practically continuously for some 17 years in connection with experimental work, pumping water from a low level tank into a tank on the top of the tower of the building. The total cost of repairs and renewals for the whole period, he said, had not amounted to £5. He also added that some six or seven years ago, he had been consulted by the Edinburgh Corporation, who were about to renew some fire engine pumps, as to the respective merits of the centrifugal and reciprocating types. He had made a series of tests extending over several months, and had found little to choose between the two for that particular purpose. He therefore advised the retention of the reciprocating type. It would probably have been advantageous to have employed centrifugal pumps if starting afresh, but he did not consider the change from one type to the other would be justified.

No other member wishing to speak, the Chairman called upon Dr. Barclay to reply. Dr. Barclay first remarked that he regarded the Rateau pump mentioned by the Chairman as of great interest, but not of great commercial value. It could not be compared with the pump giving seventeen years' continuous service referred to by Professor Hudson Beare. He agreed with Professor Gibson that the difference in efficiency between hydraulic turbines and centrifugal pumps was a dimensional effect, but added that the pump designer was hampered by the difficulty of regulation. To Professor Lea's question as to the relative merits of reciprocating and centrifugal pumps, he replied that there was usually a very great saving in favour of the latter, but he had not got actual figures with him. One point was that, if the water were good the life of the pump was indefinitely long, and even with bad water, the wearing parts could be easily and cheaply renewed. The fact that electrically-driven pumps could be started automatically was another advantage.

Dr. Owens, who then replied to the remarks on his paper, said he had read the paper by Mr. Purchas referred to by the Chairman, but did not agree with the explanation given as to the action of the air-lift pump. The speaker felt quite certain that the discharge was a mixture of air bubbles and water, and that large "pistons" of air were not obtained unless the pump was working wrongly. To Professor Lea the speaker replied that, in the particular case he had considered, the air-lift pump would have had a commercial advantage if its efficiency had been as low as 40 per cent., whereas they were actually getting an efficiency of 60 per cent. Apart from this, it must be remembered that the working conditions for a centrifugal pump were extremely bad. Its depth below ground was 150 metres, and it was necessary to protect underground machinery from the acid water dropping from the roof by covering it with a sheet of lead. The corrosive effects of the water were remarkable; even vitrous enamel placed in the pump discharge

had been dissolved in 24 hours. For handling pure water, the air-lift pump could not compete with reciprocating or centrifugal pumps, but it was far superior to either of the latter under the conditions described, since none of the moving parts was subjected to corrosive action.

Iron Bacteria and Pipe Incrustation.

After thanking the two authors for the papers just dealt with, the Chairman asked Dr. David Ellis to read his paper on iron bacteria in relation to the incrustation of pipes, and at its conclusion, since no speaker desired to take part in the discussion, he remarked that engineers should be grateful to Dr. Ellis for bringing forward this important subject. It should be realised, he said, as mentioned in a recent paper before the Institution of Civil Engineers, that, on the average, the diameter of a 36-in. main was reduced by 15 per cent. in thirteen years, and that costs could be diminished if incrustation could be avoided. The matter, of course, depended on the relative cost of increasing the diameter of the pipes and of removing the organic matter, but the subject was certainly a fruitful field for further research. The Chairman felt confident that the Institution of Civil Engineers would welcome a paper on the subject by Dr. Ellis. We publish Dr. Ellis's paper on page 457 of the present issue.

Stresses in Rails and Vibrations of Bridges.

The Chairman next asked Mr. R. V. Southwell to read two short papers by Professor Timoshenko, of Zagreb, Jugo Slavia, which formed an addition to the original programme. We hope to reprint these communications in a later issue. Mr. Southwell briefly outlined the contents of these papers, stating that the first dealt with the determination of the static and dynamic stresses in rails. In the paper it was shown that a close approximation to the stress set up by a static load on a rail could be obtained by replacing the sleepers by a continuous elastic base, so that the reaction, instead of being concentrated at various points, was distributed over the whole length of the rail. The paper went on to consider the effect of an unbalanced wheel running along the rail, and showed how the resulting stresses could be calculated, while the final portion dealt with the effect of indentations in the rail, or flats on the wheel, on the stresses produced. The second paper, Mr. Southwell explained, dealt with the more complex problem of the vibrations set up in a bridge by an unbalanced wheel travelling over it at a uniform velocity, and showed how the effects might be arrived at by replacing the wheel by a harmonic curve.

It was obviously impossible to discuss these communications, and, at the conclusion of Mr. Southwell's explanatory statement, the Chairman, after thanking Professor Timoshenko (who was present), called on Mr. J. D. Watson to read his paper on the production of power from sewage gas, which was a further addition to the original programme.

Power from Sewage Gas.

Mr. Watson then read the paper (which we reproduce this week on page 456), explaining his system and describing a plant at Birmingham in which a 34 h.p. National gas engine is used to drive a 5 in. centrifugal sludge pump by means of gas derived from two sludge digestion tanks. The plant is designed to give 25 brake horse-power for a working period of six hours a day. The useful constituent in the sewage gas, Mr. Watson explained, was methane, and, in some cases, the percentage of this was as high as 79. Usually, however, the proportion was considerably less, and at Birmingham, the percentage was 43·3. In conclusion, the author remarked that it was as yet too early to dogmatise on what were the most favourable working conditions, but the Birmingham experiments indicated that, even in a temperate climate, it was quite possible to obtain power gas from sewage. He therefore submitted that it was the duty of local authorities to see that the gas, hitherto disposed of as something of negative value, was utilised wherever practicable.

At the conclusion of the paper, the Chairman invited members to discuss it, and Professor Lea enquired what volume of methane could be obtained from a given volume of sludge. Mr. J. S. Wilson said the matter seemed to be a very important one, and it was highly desirable that such a rich gas as appeared to be available should be made use of. He also enquired how the gas was collected. The Chairman enquired if the use of the gas involved additional handling of the sludge; and also at what stage in the process of sewage treatment the gas was liberated and what was the rate of liberation. He also asked the cost per horse-power of the gas produced.

In reply to the questions asked, Mr. Watson said the sludge was brought to the digesting chamber and left in it for a week. He could not say, at present, whether a week was the correct period; it might be a day, but he would have to ascertain by experience. He had found that, by using a compressed air chamber and forcing compressed air into the bottom of the tank, so as to agitate the sludge and liberate the gas formed, the volume of gas produced was increased, but he was unable to say why this was so. At the present stage, he could not, in fact, be dogmatic as to any of the statements made, as the work had only just been commenced. He could not answer Professor Lea's question definitely, but he could say that a very small quantity of sludge, sufficed to run the engine for many hours. The plant, however, had only been running for three weeks, and the many questions which naturally arose could only be answered after more experience had been obtained.

Mine Rescue Apparatus.

The last paper taken was that by Professor Henry Briggs on mine-rescue apparatus, which was originally intended to have been read on the previous Thursday. The paper, which we hope to deal with more fully at a later date, describes two forms of rescue apparatus—one the improved "Aerophor," employing liquid air, and the other known as the "Briggs," in which oxygen is supplied from a steel bottle. The first mentioned has been evolved by the chief officers of the Newcastle and Mansfield groups of rescue stations, and improvements have been made in the receptacle for the liquid air, in the purifier for extracting CO_2 from the air, in the valves, and in the general arrangement and construction. The Briggs apparatus is fully described in the second report of the Mine Rescue Apparatus Research Committee of the Department of Scientific and Industrial Research, but additional improvements have been made since the report was issued. The headdress, mouthpiece, flexible tubes, and breathing bags are the same in both apparatus. Both, the author stated, were designed to allow the wearer to undertake hard physical work continuously for at least two hours with a considerable margin of safety. The weight of both types, when fully charged, was given as 36 lb., and both were demonstrated in actual use.

To a query as to whether any warning of the impending exhaustion of the apparatus was given, Professor Briggs replied that this was not so. With the liquid-air apparatus, if a definite weight of liquid air was supplied it must last for a definite time. It was possible to employ alarm watches for the purpose, but it must be borne in mind that all the wearers were fully trained for the work. In the compressed-oxygen apparatus the quantity of gas remaining could be ascertained by a gauge.

Invited to speak by the Chairman, Mr. F. P. Mills, of the Newcastle Rescue Station, said that, some years ago, the Home Office had compelled mine owners to provide apparatus which was somewhat unsafe. The wearer had to adapt himself to the apparatus and, if he exerted himself too much, an accident might occur. This, however, was not the case with the apparatus described by, and largely due to, Professor Briggs. With regard to the liquid-air apparatus, the speaker mentioned that this had originally been brought out by Colonel W. C. Blackett in 1910, but numerous improvements had been made since that time. It should be noticed, he said, that the breathing bag was placed on the wearer's back in the case of the oxygen apparatus, but in front of the wearer in the liquid-air apparatus. The latter arrangement, the speaker thought, was rather preferable, as the wearer had more confidence if the bag were in such a position that he could see and feel it. The speaker also referred to the use of the apparatus in petrol fumes, which were found to penetrate the rubber bags and tubes, and asked Professor Briggs what could be done to avoid this.

Mr. G. L. Brown, of the North Midland Rescue Station, who was also invited by the chairman to speak, said he would like to draw attention to the fact that the liquid-air apparatus required no regulation by the wearer. He did not consider it desirable to allow the wearer to work continuously for two hours, as one hour was sufficient, leaving another hour for him to return to the surface. The captain of the rescue team, he said, had to attend to the times of working and to check the apparatus every quarter of an hour. In the case of the liquid-air apparatus, natural evaporation supplied the air at the correct rate, and, in the compressed-oxygen apparatus, the normal supply of 2 litres per minute could be increased by the wearer, for exceptionally heavy work, by means of a by-pass valve operated by a push button. In all other respects the two types were similar.

Professor Briggs, who then replied to the discussion, said the question of the best position for the bag must be left open. It was a nuisance anywhere, but he thought it was less in the way if placed on the wearer's back. The question of petrol fumes had not yet been considered as the difficulty was not encountered in mine-rescue work. Some other material than rubber would have to be employed if the apparatus were to be used in the presence of petrol.

The chairman, after thanking Professor Briggs for his paper, said that the business of the session had been completed, but Professor G. W. O. Howe rose to propose a vote of thanks to Professor Gibson for presiding at the meetings. This was seconded by Professor F. Bacon, and after it had been acknowledged by Professor Gibson, the meeting terminated. The final excursion to Rosyth Dockyard was made in the afternoon.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Section A, the leading section of the Association, once more looks back upon a highly successful and instructive meeting. The number of papers on the list, 27, was during the week increased to 31, and that number counts each discussion as one only, though several distinct papers were submitted. One item was withdrawn; the Duc de Broglie had promised a contribution, but was unable to attend. On the other hand, the report on Tides was not mentioned in the Journal. To dispose of the agenda the section had to subdivide; two and even three subsections deliberated simultaneously on several days. The programme assigned all the papers to the mornings; but the one afternoon lecture and the afternoon demonstrations proved equally attractive. The attendances were good throughout, the halls being repeatedly overcrowded to an unpleasant extent, and the president's task was to discourage, *i.e.*, to restrict speakers as to time, rather than to encourage discussion. The value of the remarks made at a meeting cannot always be adequately appreciated when it closes; but the discussions at Edinburgh were undoubtedly of lasting value.

The officers of Section A were: President, Professor O. W. Richardson, F.R.S., of King's College, London; vice-presidents, Professors C. G. Barkla, A. S. Eddington, Sir J. A. Ewing, C. G. Knott, R. A. Sampson and E. T. Whittaker; Recorder, Professor A. O. Rankine, D.Sc., of the Imperial College of Technology; secretaries, Professor H. R. Hassé, Messrs. J. Jackson (Greenwich Observatory), M. A. Giblett, A. M. Tyndall, M.Sc., and Dr. G. A. Carse. Professor Richardson had entitled his presidential address "Problems of Physics." We supplement that title, however, by specifying the chief subjects with which he dealt, these being all regarded from one standpoint.

Problems of Physics.

Thermoionic Emission. Contact Electricity. Photoelectric Action.

Referring in his introduction briefly to recent revolutionary movements in physics Professor Richardson remarked that the theoretical researches

of Einstein and Weyl suggested that not merely the material universe, but space itself was perhaps finite. Without wishing to express any opinion as to these probabilities, he stated that geometricians had long recognised that space need not be infinite, and mathematicians had devised special geometries to meet the possible limitations of space; yet he doubted whether these inventive gentlemen ever dreamed that their schemes held any objective validity. Apart from that, the whole development of relativity was an extraordinary triumph for the pure mathematics of Christoffel, Riemann and others.

The advent of the quantum was another revolutionary change. The various consequences of the electronic structure of matter were increasing our insight into the most varied phenomena at a rate which would have appeared incredible only a few decades ago, and the enormous importance of Rutherford's discoveries could not be over-emphasised. Hydrogen nuclei had, by bombardment with α particles, been expelled from nuclei of the atoms of nitrogen and phosphorus, though not from oxygen and carbon; on the other hand there was evidence, in this latter case, of the expulsion of other sub-nuclei. The artificial transmutation of the chemical element was hence an established fact. The natural transmutation had become familiar to students of radioactivity, and the philosopher's stone was thus within our reach. But that was only part of the story. In some cases the kinetic energy of the ejected fragments was greater than that of the bombarding particles; that meant that the bombardments were able to release the energy stored in the nuclei of the atoms.

From the amount of heat liberated in radioactive disintegration we now knew that the amount of energy stored in the nuclei dealt with was millions of times greater than that generated by any chemical reaction such as the combustion of coal. The amounts of energy liberated per unit mass were in themselves small, but enormous compared with the minute amounts of matter affected. If these effects could be sufficiently intensified, there appeared two possibilities. Either the effects would prove uncontrollable, which would presumably spell the end of all things (the nervous might be reassured, Professor Richardson added, since this planet had held radioactive matter for a very long time already), or they would not. If they could both be intensified and controlled we should have at our disposal an almost illimitable supply of power. Time alone would tell.

Professor Richardson then passed on to his main subject, namely, the recent outcome of work of himself and others in connection with thermoionic emission. When he had opened a discussion on these problems at the Manchester meeting in 1915, some speakers had still claimed a chemical origin for the emission of electrons and ions by incandescent bodies. Thermoionic emission had many features in common with a typical reversible chemical reaction such as the dissociation of calcium carbonate into lime and carbon dioxide. Similarly thermoionic emission consisted in the dissociation of the neutral atom into a positive residue and a negative electron, since we knew that the electron was one of the really fundamental elements out of which matter was built up. The suggestion continued in 1915 was, however, that the emission of electrons was a secondary—not a primary—phenomenon, a kind of by-product of a primarily-chemical reaction between the source of the electrons and some other material, such, *e.g.*, as the highly-attenuated atmosphere surrounding the parent substance. In that case the source of power would not be the thermal energy of the substance, but the chemical energy of the postulated reaction. That view was no longer sustained. But establishing the primary character of a phenomenon did not determine its nature nor its immediate cause. Nobody would quarrel with the statement that, as temperature rose, the kinetic energy of some electrons would begin to exceed the work of the forces by which they were attracted to the parent substance. But how did the electrons acquire the energy necessary to escape? One answer was that the electrons found the energy required in the interior of the substance by virtue of their energy of thermal agitation. Thermal agitations now appeared less simple than formerly, however, and they did not, in any case, exhaust the possibilities.

When light of sufficiently short wave-length falls on matter, a photo-electric emission of electrons takes place. This emission caused by the whole spectrum of the hot body varied as the temperature (W. Wilson). Carefully examining the data Professor Richardson concluded, however, that the photo-electric effect of the whole spectrum was far too small to account for the thermoionic emission. We meet with the same dilemma in seeking for the *modus operandi* of evaporation, chemical action and a number of other phenomena; they might fundamentally be kinetic, or photo-chemical, or a mixture of both; the last seemed most probable. The approximation about boiling points, known as Trouton's rule,* was a fairly obvious deduction from the photo-chemical standpoint. Perrin made that standpoint the entire *motif* of all chemical reaction, as well as of radioactivity and change of state. In that he possibly went too far; but one item of chemical evidence was certainly difficult to understand from the kinetic standpoint. The speed of chemical decomposition of certain gases was independent of their volume and hence not due to molecular collisions; yet the speed increased very rapidly with rising temperature, which could hardly do more than increase the number and intensity of the collisions—since these were without effect—and increase the amount of radiation received by the molecules. But there was, according to Langmuir, nothing like enough radiation to account for the effect. The mono-molecular reactions could thus not be accounted for either by simple collisions or by radiation, or by a mixture of both, and we had to fall back on the internal structure of the decomposing molecule.

As regards the nature of the contact potential difference between two metals Volta had written in 1792: "The metals can by themselves and of their own proper virtue excite and dislodge the electric fluid from its state of rest." The contrary proposition, that electric manifestations are inseparably connected with chemical action, was developed a few years later by Fabroni. Since that time electric investigations had fairly evenly been divided between the two opposing camps. Professor Richardson considered that a study of thermoionic emission would settle the dispute. Imagine, he said, a vacuous enclosure maintained at constant temperature, and in it two bodies A and B, A emitting electrons faster than B. Since both bodies were receiving as well as emitting electrons, A would become positive, B negative; they would attract one another, and useful work would be obtained by letting them come into contact. The charges on A and B would then be discharged, and A and B could be separated again without expending work, as long as the charges had not had time to develop again. When that occurred, A and B would come together once more, and so on. We should thus have a device to convert all the heat energy from a crude and uniform temperature into useful work. That would contravene the second law of thermodynamics. We had hence either to deny the principle of thermodynamics or—a better alternative—to admit some fallacy in the arguments. In that case, we might assume, either that A and B necessarily emitted equal numbers (which would include the value zero) of electrons at all temperatures, or that the charges due to the unequal emission were not discharged, even to the slightest degree, when contact was established. The latter preferable alternative meant that bodies had natural states of electrification whereby they became charged to definite potential differences independent in magnitude of their relative positions. The intrinsic potential difference between A and B was then the same at a given temperature, whether they were in contact or apart, thus confirming Volta.

If such intrinsic potentials existed, calculation would show that they should be intimately connected with the magnitudes of the thermoionic emission at a given temperature. If A and B denoted the saturation thermoionic currents per unit area, and V was the potential difference between them at temperature T, then $V = k\,T/e \log A/B$ where k was Boltzmann's gas constant for a single molecule. Experimenting recently with Mr. F. S. Robertson, Professor Richardson had measured the potential difference between heated filaments and the metallic cylinders surrounding them, both in vacuum bulbs and in hydrogen atmospheres at low pressure. Both the contact potentials and the thermoionic emissions were, of course, very susceptible to minute traces of gas; but under the best conditions as to freedom from gas they had found a constant potential of the order of one volt between a pure tungsten filament and a thoriated filament. The constant potential calculated by the formula just given agreed within 20 per cent. with the measurements, a satisfactory agreement considering the difficulties of the experiments.

Another line of argument exemplified the close connection between contact potentials and thermoionic emission. The potential energy of an electron in the space just outside the emitter should be greater than that inside by a definite amount w, measuring the work done when an electron escaped from the emitter. The value of w could be deduced from the temperature variation of the emission, and more directly from the latent heats absorbed or generated when electrons flowed out of or into matter. The three methods gave fairly the same values for w, and different values of w for different substances. When uncharged bodies were placed in contact, the potential energies of the electrons in the two bodies would hence differ, and if in the case of metals the electrons were able to move freely, they would so move until an electric field was set up, which equilibrated this difference of potential energy. The intrinsic contact difference of potential between metals should hence be equivalent to the differences in the values of the w, and equal to that difference in w divided by the electronic charge—disregarding the Peltier effect.

Coming to photoelectric action, Professor Richardson spoke of "the threshold" frequency as the most striking feature: For each metal surface in a definite state there was a definite frequency n_0 determining the behaviour of the metal in the sense that no electrons were emitted when the metal was illuminated by light of a frequency less than n_0, no matter how intense the light, whilst light of a frequency greater than n_0, no matter how feeble, caused some emission. Thus n_0 signalised a sharp discontinuity in the phenomena. Let a metal be illuminated by monochromatic light of frequency n. The electrons might come from different depths in the metal and might collide at irregular intervals; simple properties could only be expected for the electrons of maximum kinetic energy. If v were the velocity of the fastest electron emitted, m and e its mass and charge, h Planck's constant, and V the opposing potential required to bring the electron to rest, $e\,V = m\,v^2/2 = h\,(n - n_0)$. The threshold frequency hence indicated the frequency for which the kinetic energy and the stopping potential fell to zero. That, Professor Richardson submitted, suggested that the emission ceased at n_0, not because the electrons were unable to get any energy from the light, but because they were unable to get sufficient energy from the light to escape from the metal. Further, if we measured the n_0 for any pair of metals, and also their contact potential K, K was found to be equal to the difference between the threshold frequencies multiplied by h/e.

The simple interpretation of these and other phenomena was that the electrons illuminated by light of frequency n acquired the energy $h\,n$. We had seen that the contact potential difference between two metals was nearly equal to the differences between the w/e. Photoelectric experiments showed that the contact electromotive force was also nearly equal to the differences between the n_0 multiplied by h/e. It followed that the photoelectric work $h\,n_0$ must be equal to the thermoionic work w. There might possibly be a constant difference between the two magnitudes. But, Professor Richardson argued, that difference could hardly have any other value than zero, as it should have the same value for all substances and frequencies; the indirect evidence for the identity was, however, stronger than the direct,

* According to Trouton the latent heat of vaporisation of 1 gramme-molecule of a liquid, divided by the corresponding boiling point on the absolute scale, is a constant C = 21 for non-associated liquids and vapours.

so far. On the other hand, the identity between w and $h\,n$ could not be inferred *a priori*. Much depended upon the condition of the electrons in the metals, about which we had various theories, none of which were more than mere guesswork. Further, though the threshold value was a definite quantity, it was so only under specified conditions; the n_0 was no doubt extremely sensitive to minute changes in the conditions of the surface, such as films of foreign matter. For that reason we should be cautious with regard to statements sometimes made that photo-electric action was a parasitic phenomena, inasmuch as it could be made to disappear by improving the vacuum or by other changes in the conditions. In such cases something had mostly been done to the surface which raised its threshold value above the shortest wave-length in the light employed in the test. Frenkel had brought surface tension into close connection with w. Such a connection should exist; but it might not be so simple as suggested.

The further investigation of X-rays, Professor Richardson continued, promised more precise information about these problems. X-rays had been recognised as being merely light of very short wave-length, and the gap between ultraviolet light on the one side and X-rays on the other had now been narrowed to four octaves. After Schumann and Lyman, Bazzoni and Professor Richardson himself had extended the helium spectrum down to 450 Angström units; Millikan had reached 200 A.U., whilst on the X-ray side Friman had measured a ray of the L series of zinc of 12·346 A.U. The common characteristic property of these rays, their high absorption by all kind of matter, was not surprising from the quantum standpoint. The quantum of these radiations was in excess of what corresponded to the ionising potential of every known molecule; yet it was of the same order of magnitude and large enough to reach the deeper-seated electrons of the atom. There was evidence, theoretical and experimental, that the photoelectric absorption of radiation was most intense when its quantum exceeded the minimum necessary to eject the absorbing electrons, but did not exceed it too much. In the simplest theoretical case the absorption was zero for radiations of frequencies lying below the minimum quantum; it rose to a maximum for a frequency comparable with the minimum, and should fall off again to zero at infinite frequency. All rays between ultraviolet and X-rays should hence be subject to intense absorption. The closeness of the similarity between X-rays and light, Professor Richardson finally remarked, was yet inadequately realised, and every advance tended to unify rather than to disintegrate these two groups of phenomena.

If in recording the proceedings of Section A at Edinburgh we follow the sequence of problems as dealt with by Professor Richardson in his presidential address, which we have summarised above, we must first notice relativity, and then radiations and the quantum hypothesis. We will attempt to group the subjects discussed on these lines, interposing papers on radiotelegraphy and ionisation, and passing subsequently to communications on methods of measurement, on meteorology and geophysics, on the age of the Earth, on astronomy and on pure mathematics.

Einstein's Theory of Relativity.

Professor A. S. Eddington delivered his lecture on Monday afternoon before a packed audience—over-estimated, no doubt in the Press, at 2,000—which was thoroughly interested throughout. The lecturer, indeed, did his best to justify the hope expressed by Professor Richardson, when calling upon him, to "make the fascinating subject comprehensible." We must confine ourselves to a few notes. Speaking for over an hour without resorting to mathematics, Professor Eddington remarked that we had inherited the aether. Maxwell's u was to represent our (the Earth's) velocity relative to the aether, of which Michelson-Morley and others had failed to find any evidence, and the u was in fact a dummy and of no consequence. Einstein did not deny the aether—Professor Eddington had put the plain question to him; the aether might have many properties, but it was premature to give names to them. The contraction of matter in the direction of its movement was not peculiar, considering that the electric forces, assumed to maintain the form of a body, were seated in the aether. Number alone was absolute, length relative; we had recently learnt how relative the value of the pound sterling was. We might expect a person to count the number of pages or letters in a book correctly; but when we asked him to measure the distance between two spots on a page, he would or should ask for definite instructions as to the mode of measurement. If the distance London-Bristol were 120 miles at noon, it would be slightly less at 5 p.m. That was of no practical account as long as we limited ourselves to our Earth. If we measured on Sirius, however, where the standard metre might differ from ours, and in general when we studied things outside our Earth, we had not merely to draw the line "here now" between past and future. In four-dimensional space we had to distinguish between "my now" and "your now," represented diagrammatically by two lines intersecting on the past-future axis, and the zone between these two lines extended as we penetrated further into space. There was no simultaneity in space. Space appeared curved when we based ourselves on Euclidean geometry. The curvature need not necessarily be spherical. At any place the atom or electron was measuring itself against the radius of curvature, and Einstein's law of gravitation might be summarised in the words: the curvature of the world in all directions and in all places is constant.

Sir Oliver Lodge, who seconded the vote of thanks for Professor Eddington's admirable address, proposed by Professor J. C. Kapteyn, of Groningen, did not find much comfort in that definition. He considered motion as a property of matter; the æther was not moving, and physics—not geometry, as Professor Eddington had said—was based on measurements. Sir Oliver added that the German Government had offered Einstein a prize of 200,000 marks. This Einstein had declined to accept, but the money was to be spent in experiments on the shift of the spectrum lines, the third so far controversial main consequence of the relativity principle suggested by Einstein.

Relativity Contraction in a Rotating Shaft.

The mathematical paper on the "Relativity Contraction in a Rotating Shaft Moving with Uniform Speed along its Axis," by Dr. Felix E. Hackett, of Dublin, dealt with its problem in terms of a fixed æther and the Fitzgerald-Lorentz contraction, observations being supposed to be made by a fixed and a moving observer. Dr. Hackett suggested a hypothetical modification of Fizeau's method of measuring the velocity of light, a rotating shaft carrying two discs with apertures corresponding to the toothed wheel of Fizeau; the arrangement would measure time like an ideal clock, by means of a beam of light reflected by two mirrors, and an additional disc fixed to the shaft would indicate the local time at that spot. The rotating shaft in axial movement would, to a stationary observer, appear twisted in the opposite sense to the rotation, as R. W. Wood had pointed out, and the longitudinal contraction and twist of the shaft, which would be independent of the form of the shaft, were considered by Dr. Hackett as a strain-displacement in a thin tube or solid cylinder. All the motions discussed being uniform, Euclidean geometry and Einstein's restricted relativity of 1905 were applicable.

The Time Interval in Fluorescence.

Passing to the communications on radiation, we first notice two papers by Professor R. W. Wood, For. Mem. R.S., of Johns Hopkins University, Baltimore, who proved so remarkably skilful in drawing with coloured chalk that one hardly missed the actual demonstration of the spectroscopic phenomena he described.

In the paper on "The Time Interval between the Absorption and Emission of Light in Fluorescence," Professor Wood explained that absorption and emission were distinct, yet separated by too short an interval for discrimination by ordinary means. In the case of mercury vapour he had, however, been able to prove that it bursts into luminescence in 1/15,000 sec. after excitation by illumination, and similar experiments made on liquids and solids had yielded shorter intervals. It had been erroneously believed that mercury vapour burst into spontaneous fluorescence (bluish green) at a certain temperature; but the vapour was not fluorescent in a static condition. Nor did it appear that the absorption of light (rays between 1,800 and 2,100 A.U.) simply ejected an electron which, on its return, caused fluorescence. There was no fluorescence in mercury vapour, unless some fluid mercury were present, which probably liberated some diatomic atoms essential for the phenomenon. When mercury was heated in a quartz bulb a faint luminescence appeared at 170 deg. C.; at 180 deg. the glow was ten times stronger, though the vapour density had not much increased meanwhile, and with a fall of the temperature of 2 deg. the fluorescence vanished again as soon as condensation began. When two bulbs were connected by a horizontal tube, and mercury heated in them, illumination by an aluminium spark showed no fluorescence if both the bulbs were at the same temperature of about 200 deg. But when the one bulb was then cooled by cold air, the other immediately fluoresced, because in the latter bulb new vapours were formed, the more rapidly, the more the temperature exceeded 180 deg.

In studying the time interval, Professor Wood made use of an inverted U-tube (Fig. 1), ending in bulbs, one, A, of which was heated by a gas burner. The rays from an aluminium spark crossed the vapours after passing through a slit in the

Fig. 1.

screen S. The vapour rushed up the A limb and down the other, where it condensed. With the arrangement described the fluorescence was limited to a greenish flame, resembling a Bunsen flame with an inner dark cone; when the screen S was removed the whole tube would shine. The speed of the mercury particles, smaller near the walls than in the middle of the tube, could be estimated from the rate of distillation, and the shape of the flame could thus be accounted for. Better time estimates were obtained with the aid of the synchronophosphoroscope. This was a disc of bakelite, rotated (at 1,800 r.p.m.) by an electric motor and provided with a radial slot near the rim, and further with the two pairs of contacts of a sparking device. The slit was in front of the tube, when itself vertical; the eye was placed close to the slit; no fluorescence was seen until the eye was shifted a little in the direction of the disc motion. To facilitate the observations a second slit and a lens were added.

Examined in this way the vertical slit on the rim appeared converted into an oblique band of light, starting not at the foot of the slit, but some distance away from it, and from this distance and the obliquity of the band, as well as from the speed of the disc, the time interval between illumination and fluorescence was estimated at 1/15,000 sec. In experimenting with a bulb, containing mercury vapour of a higher density than the tube, the interval was reduced to 1/40,000 sec. Experiments were then made with liquid jets, the 6-cylinder pump finally used giving a jet of a velocity of 250 m. per second, which would cut through the hand like a circular saw. The slit displacements observed in these cases, with solutions of fluorescein, eosin, etc., were exceedingly small, of the order of 0·1 mm., and would correspond to time intervals of less than one millionth second. To test solids, crystals or splinters of uranium glass, willemite, anthracene, barium-platino cyanide, etc., were attached to the disc; in some cases again the intervals were estimated at 1/400,000 second.

During the discussion of the paper it was suggested that there might be an instantaneous response to absorption by an emission of light of some other wave length; if all depended upon the return of the electron to its original orbit we should have maxi-

mum omission at once. Professor Richardson said that he would rather ascribe the fluorescence to displaced electrons than to diatomic molecules, and Professor Wood, in his reply, mentioned that mercury vapour, when excited by its own radiation of 2,536 A.U., would at once, without interval, emit the resonance radiation. We should add that varied work had been done, as Professor Wood mentioned, on mercury vapour and fluorescence, but this first observation of darkness during the illumination is due to him.

HYDROGEN SPECTRA IN LONG VACUUM TUBES.

This second paper by Professor Wood was not less interesting than his first, but the phenomena dealt with were more complex and less clear. It is well known that of the 32 hydrogen lines of the Balmer series seen in the solar spectrum only the first twelve can be obtained in the laboratory. The reason is, according to Professor Wood, that the continuous spectrum and the secondary spectrum, also produced, mask the feebler higher series lines.

In his paper Professor Wood described his tubes of 2·5 m. length, which are so bent that a horizontal middle portion is, by vertical limbs, separated from the ends containing the cylindrical aluminium electrodes; this central portion is viewed end on. He had first thought very high rarefaction favourable, but he found it more suitable to maintain connection of the tube, at the one end with an electrolytic hydrogen generator and at the other with a Gaede pump. The central portion showed up to 20 Balmer lines. Starting with a feeble current the secondary spectrum was first seen alone; as the current increased, the Balmer series developed, increasing in intensity, whilst the secondary spectrum faded to a minimum, subsequently gaining in intensity once more. The excitation was from the secondary of a transformer, currents up to 20 amperes at 25,000 volts being used; the limbs then appeared bluish, the central portion purple. When the primary switch was opened and then closed again quickly, an almost explosive flash appeared, followed within 0·1 sec. by a very bright Balmer spectrum. This could be repeated many times—20 times per second—but the flash was only observed when a trace of water vapour (the hydrogen had to be dried) was present, or oxygen was admitted. During that flash the current might rise to 3,000 amperes. The ordinary condenser effect, Professor Wood thought, was due to increased current intensity. There were further peculiar bright spots in certain parts of the tube; the sodium and silicon lines appeared; when the tube was run for days, and the hydrogen dried, the spectrum finally turned white, and stratification might set in suddenly, though nothing was changed in the experimental conditions. Finally, a new spectrum, more complicated than the secondary, was emitted. There was no discussion of the perplexing variety of hydrogen spectra.

RECEPTION OF WIRELESS WAVES ON A SHIELDED FRAME.

Mr. Alan. A. Campbell Swinton, F.R.S., described experiments made by him on the suggestion of Mr. N. P. Hinton that a frame aerial placed within a metal tube or spiral might become a wireless telescope or a superior direction-finder. The frame used consisted of a circular coil, 7 in. in diameter, with 100 turns of cotton-covered wire, which could be reduced to 80, 40 or 20 turns. The 80 turns responded well to the signals from the Eiffel Tower in Paris (wave-length 2,600 m.), especially with radio-valves in circuit. The shielding tube first tried was a wooden box, 18 in. square, 4 ft. long, wound with turns of bare copper wire, 1 in. apart and earthed. Placing the frame mentioned within this box, with box ends open, made no difference in the intensity of the signals. When the bare wire ends were short-circuited, the intensity went down by one-half and more; the tube itself, moreover, showed no directional properties, and turning the tube or closing the tube ends by wire grids did not affect the signals. Even wrapping the tube with iron wire netting of ½ in. mesh, joined to the copper wire, left the signals audible, though only faintly. Thus the screening effect was weak for these long waves of 2,600 m., whilst Lodge had shown in 1888 that Hertzian waves of a few centimetres were screened under similar conditions.

The wooden box was then replaced by a case, 2 ft. cube, of sheet copper, $\frac{1}{16}$ in. thick; one face was left open or closed by a lid of the same copper; the case was earthed. The frame was placed inside the case, the condensers, amplifiers, &c., remaining outside. Again, the signals were audible though faint (reduced to about 5 per cent.) when the open side was turned towards Paris. When the lid was put on, they decreased much, and vanished the moment actual contact between lid and case and a continuous metallic shield had been established. A lid of tin foil on wood was equally effective. With the open case pointing at right angles to the direction of Paris, nothing was heard; at an angle of 45 deg., the intensity was reduced to 1 per cent.; when the open end faced upward the faint signals vanished on putting on the lid. When the cube was replaced by a tin plate, 5 ft. long, 8 in. wide, bent to a tube, distinct shielding only occurred when the ends were in actual contact (mere overlapping was not sufficient) especially when the cylinder diameter was reduced. All these experiments suggested that the damping was due to eddy currents and indicated that there was in addition to what was analogous to a "push" upon an aerial in front of the wave, also something of the nature of "pull" upon an aerial behind the wave front. Further, that the shielding tube did not improve directional reception, though matters might be different if more space were left between the frame and the shield to avoid damping.

In commenting upon this paper, Sir Oliver Lodge said that he had in his "copper hat" experiments of 1888, found that the waves would not get into a soldered-up box, nor did they like a round hole, but they would creep in if a wire protruded from the hole. A circular coil was a magnetic detector, and an aerial was an electric detector; no metallic box could screen static magnetism, but oscillating magnetism could be screened; if Mr. Swinton's box were turned, it would screen static magnetism.

PITH BALLS IN AN IONISED ATMOSPHERE.

In their demonstration of the "Behaviour of an Electrified Pith Ball in an Ionised Atmosphere," Dr. Dawson Turner and Mr. D. M. R. Crombie, of Edinburgh, used pith balls attached to short threads of silk which were fixed by sealing wax to the upper end of a vertical rod or cylinder of brass; the brass was electrified from a Wimshurst machine, so that the balls diverged. When a source of ionisation, such as an arc light, a Nernst filament, an incandescent platinum wire, a burning magnesium wire, Bunsen flame, X-rays, &c., was approached, the balls began to dance. A Leiden jar in circuit exerted a directing influence along a line joining the jar rod and the source. The action of the light is not actinic, *i.e.*, not dependent upon the intensity of the light; the ions seem to be carried upward by convection currents unless drawn downward by electric attraction; in a Bunsen flame the maximum effect is in the dark zone, a little above the mouth of the burner. When the source is placed between two metal screens, the effect is stopped, probably owing to static charges; the sign of the electrification by the machine seems to make no difference.

THE QUANTUM THEORY.

The discussion on the Quantum Theory, on which more than 2 hours were very well spent, only partly admits of summarising. In opening the discussion, Mr. C. G. Darwin, of Cambridge, stated that the deductions from the principles of classical dynamics had led to some results which were contrary to experiments and sometimes impossible. The quantum theory of Planck, developed during the last twenty years, had in such cases an extraordinary power of giving the right results. But the theory had no complete logical foundation; some of the results looked preposterous; yet working models dispensing with the quantum theory either proved to be out of order when put to the test or demonstrated all sorts of things they should not do. The facts explained by the quantum theory fell into two groups, photo-electric effects and the theory of spectra on the one hand, and radiation and specific heat involving considerations of the meaning of temperature on the other.

The essential feature of the theory was the existence of the universal quantum $h = 6.55 \times 10^{-27}$ erg-second, which in some way, not yet explained, controlled the exchanges of energy. For a system vibrating at frequency ν, the energy exchange took place in amounts $h\nu$. So far that applied only to periodic systems. In the photo-electric effect, light falling on a metal surface expelled electrons at a high velocity; in the X-rays the same effect was enormously enhanced, and the converse also held—electrons of a given energy would only excite X-rays of a frequency below a certain limit.

Planck discovered the quantum in studying radiations. Though these were complicated by the conception of temperature, Poincaré had proved that anything even remotely resembling the facts of radiation could only be explained—and was explained precisely—by Planck's ideas. That held again for the specific heat of solids. The specific heat of gases was rather different as there rotations, not vibrations, had to be "quantised." As regards radiation, Planck subsequently attempted to reconcile the new and the old mechanics by admitting a continuous absorption, while still insisting upon discontinuous emission. That second hypothesis would not work in the spectrum theory, while giving good results in other fields; closely connected with it was the question of a residual energy at absolute zero of temperature, a question that experiment should soon be able to decide.

The spectrum theory was leading to extensions of quantum mechanics. Bohr argued that an atom emitted at frequency ν because it had lost energy $h\nu$; that accounted for the combination law of Ritz—that the frequencies of the spectrum lines were given by the differences between pairs of terms of a sequence; the study of a line was thus replaced by the study of the atomic energy before and after emission. Since, however, on classical principles the nuclear atom lacked definiteness, a further use of the quantum was required; the orbits were thence quantised, *i.e.*, the number of orbits possible dynamically was limited by imposing non-dynamical conditions. The dynamical solution of the motion of a system of n degrees of freedom involved $2n$ constants, and quantisation consisted in fixing half of these by a certain rule in terms of the quantum in order to arrive at the only *permissible* orbits. If, *e.g.*, the hydrogen spectrum were due to a single electron describing planetary orbits, the major axes would have length of 1, 4, 9 times $0{\cdot}53 \times 10^{-8}$ cm., and eccentricities of definite values. In this case the quantisation could be effected in several ways, each leading to a different set of permissible orbits; but the energy of each had the same set of values, and so they gave the same spectrum. These cases, known as "degenerate," formed one of the difficulties of the quantum theory. The theory had been extended by Sommerfeld and others to the fine structure of the hydrogen lines, to the enhanced lines of helium, X-ray spectra, and to the alkali spectra. Bohr himself had recently extended the theory by his principle of analogy (between the new views and the (fallacious) predictions of the electro-magnetic theory), the physical meaning of which was hard to see. In the Zeeman effect the quantum theory and classical mechanics led to the same results, because the quantum occurred on both sides of the equations and cancelled out; in the same way many phenomena which dynamics could explain might really be quantum phenomena. The quantum was also connected with Weyl's extension of the relativity principle. The property of rigidity played a certain part in relativity, and was typified in the expression "radius of the electron." The quantum theory gave a true measure of this characteristic: the radius of the orbit which the electron described about the nucleus.

Sir Oliver Lodge then presented two communications by Sir Joseph Larmor. In the first, on "Escapements and Quanta," Sir Joseph put the question: Might not an atom be a clock? An electron fixed into an atom was sometimes supposed to be retained in the atom, and to emit its energy again in Röntgen rays, mostly forming a group of very definite periods, but in part irregular. The former periods were sharp in tens of thousands of undulations, yet an intensely radiating system could be quenched in a few vibrations if left to itself. How was that to be imagined? Consider a clock with a compound pendular system, having a group of sharp periods in

its complex mode of oscillations. Vibrating freely, that pendulum would slowly come to rest; engaged through an escapement with a coiled spring, it would go on for weeks, picking up from the spring just the small quantum of energy needed. Now a Rutherford atom was made up of a shell, the seat of chemical and radiant properties, and a core, sheltered, perhaps, too stiff, anyhow, to reveal itself except in the inertia belonging to its structure. The outer shell of electrons stood for the pendular system, maintained in absolutely continuous vibration from the energy of the core, imparted gently through an escapement action and renewed every time the core was wound up by entrapping a particle with its translatory energy. All that was parabolic, yet fertile on analogy. But a connection between the feed of energy and the free period $\epsilon = h\nu$ was wanting. Perhaps the clock might be reversible, and by absorbing incident radiant energy of proper periods into its pendular system was able to wind up its spring; that would point ultimately to unstability and ejection of a particle from the core. Such quantised maintenance of a vibrating system was far removed from the orthodox smooth vibrator, but not uncommon in Nature: a blown organ pipe and a bowed string emitted regular trains of waves maintained as long as desired. The escapement might be modified into a smooth continuous mathematical mechanism of constraint, working without any jerk.

In his second communication on "Non-Radiating Atoms" Sir Joseph Larmor discussed the possibility of orbital systems of electrons which would not radiate unless when disturbed. Atoms having a permanent symmetry with regard to three planes might, he showed mathematically, readily be imagined such that their radiation was so small as to rank with the residual effects marked by electrodynamic relativity. An atomic orbital structure could subsist only at or near one of these sets of non-radiating configurations; by intense shock it might be imagined to be pushed over from one set into another with a loss of energy that went in part into the disturbing system and in part into radiation. Coming back to the Rutherford atom and the organ-pipe analogy Sir Joseph showed, on Helmholtz's exposition, that the vibrating jet of air, though alternating, need not be discontinuous. Thus a new type of vibrating system was suggested, a periodic system linked by slight continuous coupling with another system of similar type, perhaps, and of large energy capacity, but not of periodic quality. Sir Joseph's concluding general remark was that, wherever it was necessary to treat of discrete quanta of energy, they might well be packets separated in the cases concerned by the atomic mechanism—just as period in natural radiation was said in a sense to be a creation of the resolving prism or grating—without having to face the difficult assumption that energy itself was necessarily discrete.

(To be continued.)

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

(Continued from page 417.)

CONTINUING our description of some of the material on view at Olympia we may first refer to the good display of air compressors of various types made by Messrs. Reavell and Co., Limited, of Ranelagh Works, Ipswich. From among the machines exhibited we have selected three for illustration. The first of these, shown in Figs. 31 to 33 annexed, is a turbo blower or compressor, intended for scavenging work in connection with two-cycle engines, while somewhat similar machines have been supplied in connection with coke-oven installations. The machine is driven at 4,600 r.p.m. by a 120 h.p. motor, through gearing. It has a capacity of 3,080 cub. ft. of air per minute, and is suitable for a pressure range of from 2 lb. to 6 lb. per square inch. The general arrangement of the machine will be seen from Fig. 31, while the details will be followed from Figs. 32 and 33. Of the two other machines illustrated, Fig. 34, on page 436, is a marine auxiliary compressor for direct coupling to a Petter Junior oil engine and intended for use on Diesel engine ships for charging. The machine is of the horizontal type and is on the enclosed forced-feed lubrication system. It has a piston displacement of 8 cub. ft. per minute and is suitable for a continuous working pressure of 60 to 70 atmospheres. The machine shown in Fig. 35, page 436, is also an auxiliary compressor intended for use on Diesel engine ships. It is of the 3-stage vertical type, and the compressor exhibited is coupled to a motor. The compressor has a piston displacement of 110 cub. ft. per minute and is also constructed for a working pressure of 60 to 70 atmospheres.

Although the present is not an electrical exhibition there are none the less a fair number of pieces of electrical apparatus on view, while naturally electrical material plays a considerable part in many machinery exhibits. An example of the type of exhibit which may be classed either as mechanical or electrical is furnished by the 3-ton electrically-driven cargo winch shown on the stand of the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester, and of which a view is given in Fig. 36, on page 436. This winch represents, we think, a new line of manufacture by the Metropolitan-Vickers Company, although they have, of course, for very many years supplied such closely allied material as haulage gears of various kinds. The mechanical parts of the winch were made by Messrs. Harfields, Limited, of Blaydon-on-Tyne, and the electrical equipment by the Metropolitan-Vickers Company themselves.

The rough handling to which deck machinery

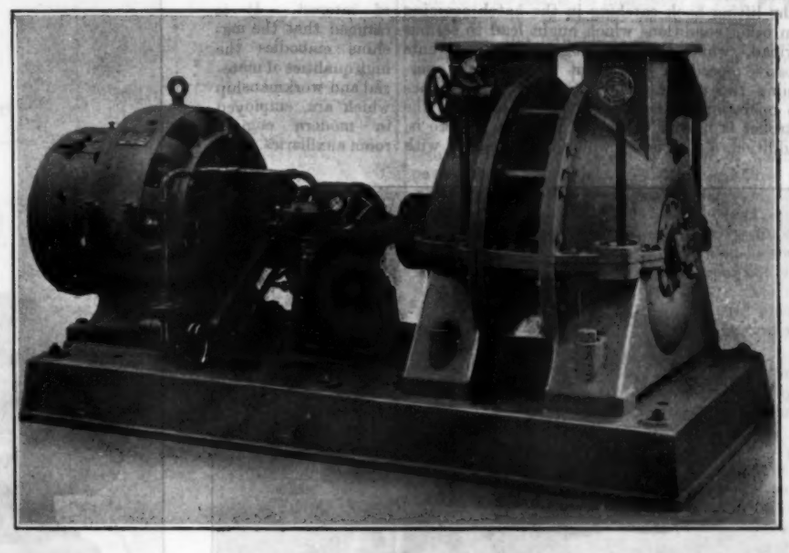
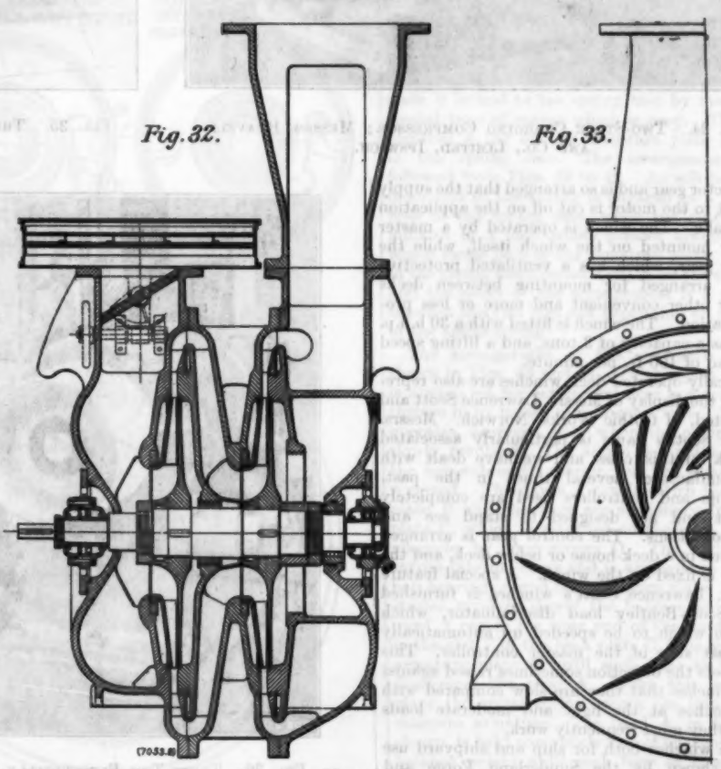


FIG. 31.



FIGS. 31 TO 33. TURBO-BLOWER; MESSRS. REAVELL AND CO., LIMITED, IPSWICH.

is subjected is notorious, and the winch has been built with the special conditions in view and with the controls arranged so that it can be operated by any class of labour without fear of damage either to the cargo or the equipment. The motor is fitted with a self-contained slipping clutch, a magnetic brake and a centrifugal brake. The slipping clutch comes into operation in the event of the lifting hook catching in the hatch coaming or in other conditions which might lead to serious overload, while the centrifugal brake prevents excessive speed in the event of the load overrunning the motor. The magnetic brake comes into operation on failure of voltage or when the controller is moved to the off position. There is, in addition, a foot brake which is interlocked with the contactor gear and is so arranged that the supply of current to the motor is cut off on the application of the brake. The winch is operated by a master controller mounted on the winch itself, while the contactor gear, which has a ventilated protective cover, is arranged for mounting between decks or in any other convenient and more or less protected location. The winch is fitted with a 30 b.h.p. motor, has a capacity of 3 tons, and a lifting speed at full load of 100 ft. per minute.

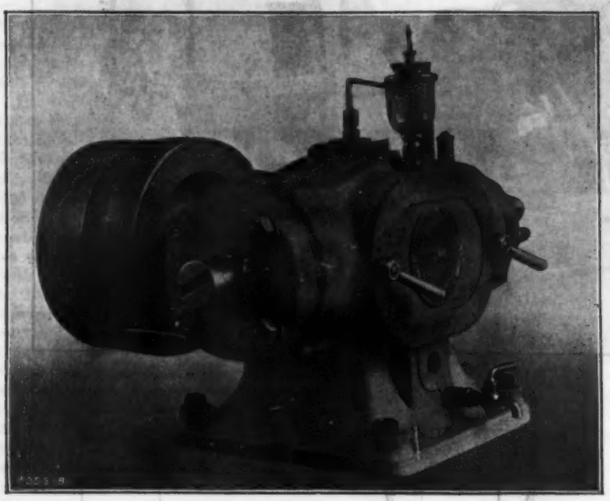


FIG. 34. TWO-STAGE CHARGING COMPRESSOR; MESSRS. REAVELL AND CO., LIMITED, IPSWICH.

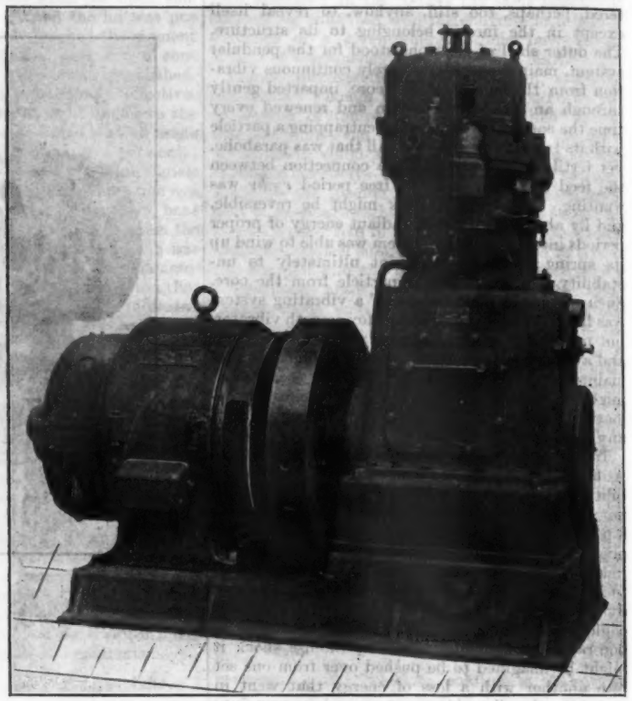


FIG. 35. THREE-STAGE VERTICAL COMPRESSOR; MESSRS. REAVELL AND CO., LIMITED, IPSWICH.

Electrically-operated deck winches are also represented by the display of Messrs. Lawrence Scott and Co., Limited, of Gothic Works, Norwich. Messrs. Lawrence Scott's name is particularly associated with work of this class, and we have dealt with their manufactures several times in the past. The motors and controllers used are completely watertight and are designed to stand sea and tropical conditions. The control gear is arranged to be placed in a deck-house or below deck, and the controller is fixed on the winch. A special feature of Messrs. Lawrence Scott's winches is furnished by the Scott-Bentley load discriminator, which allows the winch to be speeded up automatically on the last step of the master controller. This device meets the objection sometimes raised against electric winches that they are slow compared with steam winches at the light and moderate loads at which they must frequently work.

Electric winches both for ship and shipyard use are also shown by the Sunderland Forge and Engineering Company, Limited, of Pallion, Sunderland. This firm also shows various examples of its well-known steam-driven electric generating sets for ship use. An 18-h.p. electrically-driven two-speed ship winch is shown by Messrs. Clark, Chapman and Co., Limited, of Victoria Works, Gateshead. This winch has a single lever control and lifts 3 tons at 60 ft. per minute and 1½ tons at 120 ft. per minute. This firm also shows other of their well-known specialities, such as capstans, feed pumps, &c. A somewhat novel type of ship winch is shown by Messrs. Babcock and Wilcox, Limited, of Renfrew. This is a steam winch of which the novelty is that it is totally enclosed. The ordinary ship's steam winch is subjected to very rough and onerous conditions and this attempt to protect the machine and thus enable it to be kept in better condition is of interest. It is claimed that the machine embodies the high qualities of material and workmanship which are employed in modern engine-room auxiliaries. Another important exhibit on Messrs. Babcock and Wilcox's stand is an example of the Riley stoker, the manufacture of which the firm has taken up. This stoker, which is well known in the United States, is of the underfeed type, and it is claimed that the slicing action of the reciprocating grates which are employed is such that combustion can be maintained at a very slow rate for long periods and brought up to maximum intensity in a very short time. Messrs. Babcock and Wilcox also naturally make a feature of their boiler on their stand.

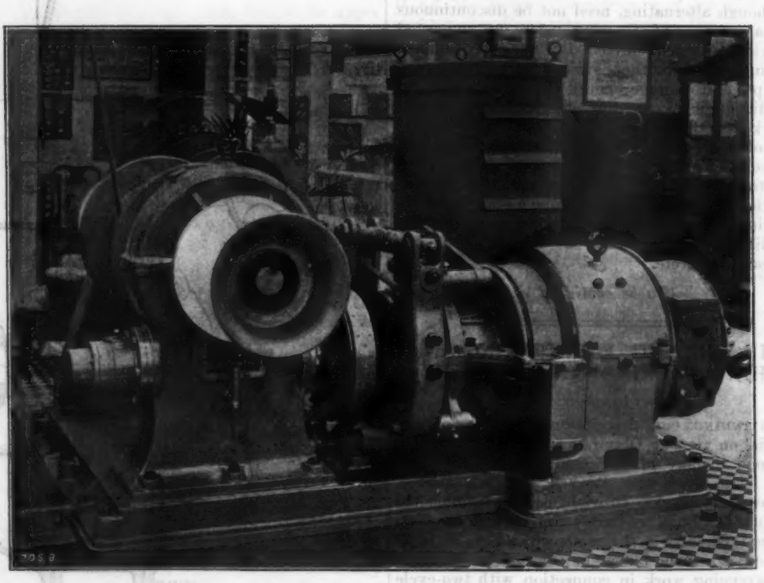
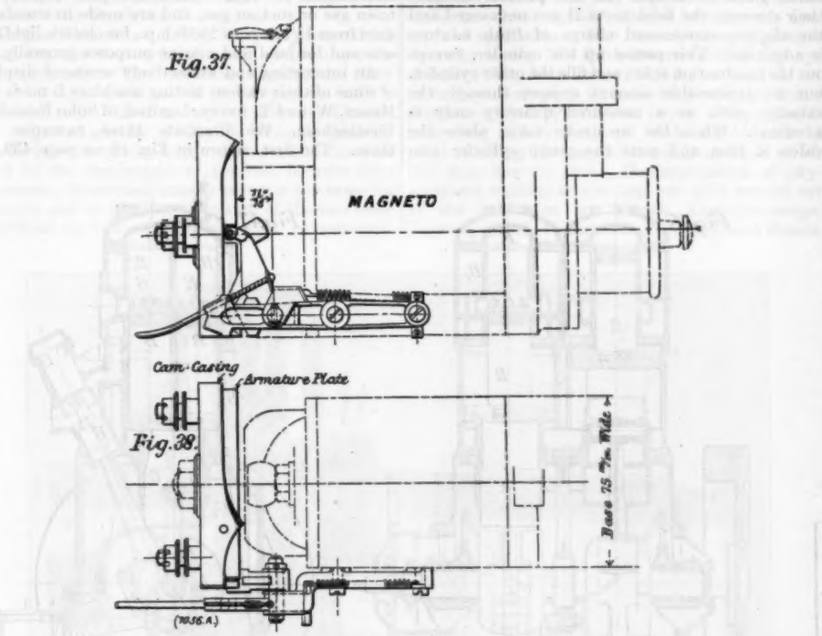
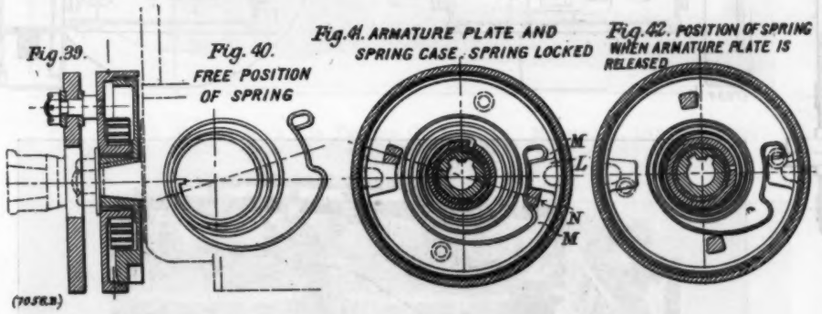


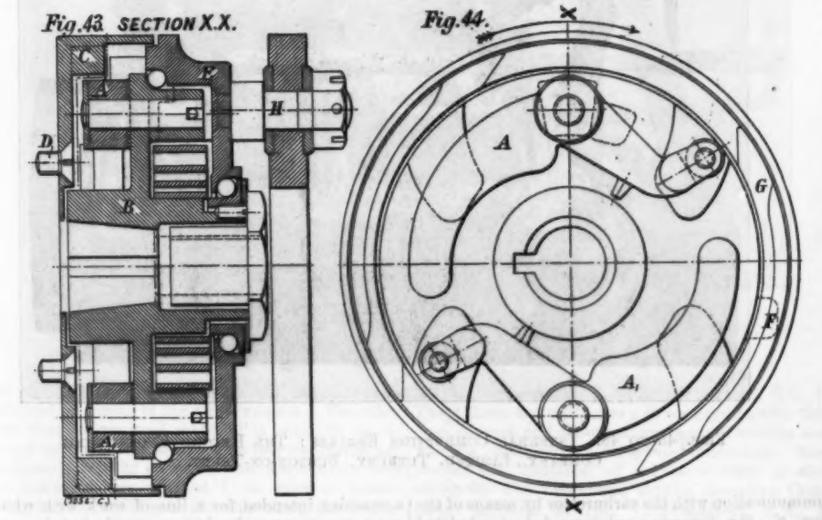
FIG. 36. THREE-TON ELECTRICALLY-DRIVEN CARGO WINCH; MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, TRAFFORD PARK, MANCHESTER.

Other boiler exhibits are made by Messrs. John Thompson, Water Tube Boilers, Limited, of Wolverhampton, and allied firms. Messrs. John Thompson's water tube boiler is of the straight-tube type, and is built in sizes up to an evaporative power of 100,000 lb. of water per hour. The firm also shows a Kennicott water-softening plant, &c. Water-tube boilers are also represented by the British Niclausse Boiler Company, Limited, of

EXHIBITS AT THE OLYMPIA EXHIBITION.







FIGS. 37 TO 44. PETROL ENGINE STARTING DEVICE: THE RECORD ENGINEERING COMPANY, LIMITED, TUTBURY, BURTON-ON-TRENT.

the Clock House, Arundel-street, Strand, London. A Spencer-Hopwood vertical water-tube boiler, capable of evaporating 1,050 lb. of water an hour, is shown on the stand of Messrs. Spencer-Bonecourt, Limited, of Parliament Mansions, Victoria-street, S.W. 1. The boiler is intended mainly for providing auxiliary steam on shipboard. The firm also show a waste heat boiler intended to work on the exhaust from a 200-h.p. Diesel engine. The boiler works at 120 lb. per square inch and generates about 1 lb. of steam per brake horse-power developed on the engine. In connection with boilers we may also mention the well-known Hotchkiss circulation system which is shown by Messrs. Arthur Ross, Hotchkiss and Co., Limited, of 1, Glengall-road, Old Kent-road, S.E. 21.

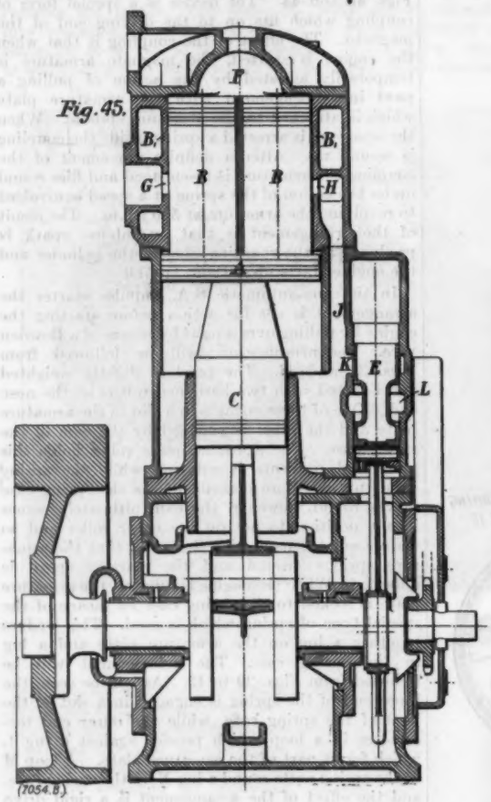
A small but very ingenious device for use in connection with the starting of motor cars and petrol engines generally is shown by the Record Engineering Company, Limited, of Tutbury, Burton-on-Trent. This device, which is known as the S.A. impulse starter, is illustrated in Figs. 37 to 44, annexed. It is made in two forms, non-automatic and automatic, of which the former is illustrated in Figs. 37 to 42, and the latter in Figs. 43 and 44. The device is a special form of coupling which fits on to the driving end of the magneto. The effect of the coupling is that when the engine is started, the magneto armature is temporarily arrested by the action of pulling a pawl into engagement with the armature plate which is attached to the armature spindle. When the armature is arrested a spring inside the coupling is wound up. After a definite movement of the coupling the armature is disengaged and flies round under the action of the spring at a speed equivalent to revolving the armature at 500 r.p.m. The result of the arrangement is that an intense spark is produced at the sparking plug in the cylinder and the engine starts up without trouble.

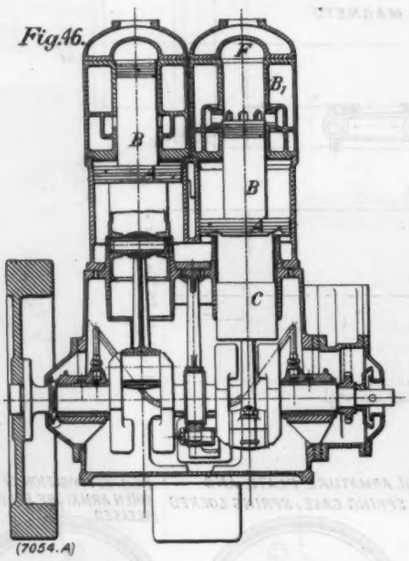
In the non-automatic S.A. impulse starter the arrangement is set for action before starting the engine by pulling over a pawl by means of a Bowden wire. The arrangement will be followed from Figs. 37 and 38. The pawl is slightly weighted and is fitted with two hardened rollers at the nose end. One of these engages in a slot in the armature plate and the other is engaged by the cam of the spring case. The armature plate roller holds this plate and prevents it rotating while the spring winds up as before described. As the spring case moves round, however, the cam ultimately comes into a position to act on the other roller and so throws out the pawl with the result that the armature springs around and the starting spark is obtained. When the engine is running, the armature plate is locked to the spring case by means of the special type of spring which is used. This wedges together a lug on the armature plate and a lug in the spring case. The arrangement will be followed from Figs. 39 to 42. As will be seen, the inner end of the spring is engaged in a slot in the boss of the spring case, while the outer end terminates in a loop which presses against a lug L which forms part of the armature plate. A loop M in the spring nests round a lug N on the spring case, and the effect of the arrangement is a rigid drive between the two lugs not depending on the tension in the spiral spring.

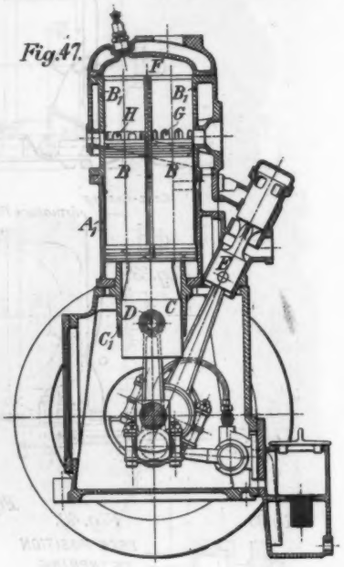
The arrangement of the automatic starter is shown in Figs. 43 and 44. In this case the starter is always set for action and does not require to be thrown in by means of a Bowden wire. The starter operates, however, only when the engine is being slowly revolved. The action is similar to that of the non-automatic starter, but the arrangement is reversed. The pawls A revolve with the armature plate B and the slots are stationary in the back plate C, which is attached to the nose end of the magneto by four screws D. The spring case E carries internal cams and is arranged to revolve on ball bearings round the armature plate. When the starter revolves slowly the balance weight on the pawl A causes the nose end of the pawl to engage in the slot F of the back plate C, thus arresting the armature plate B until such time as the cam G disengages the pawl A. When this action takes place the spiral spring causes the impulse to the magneto armature. The pawl A, in the position shown, is held completely out of engagement by its balance weight until such time as it assumes the position of pawl A.

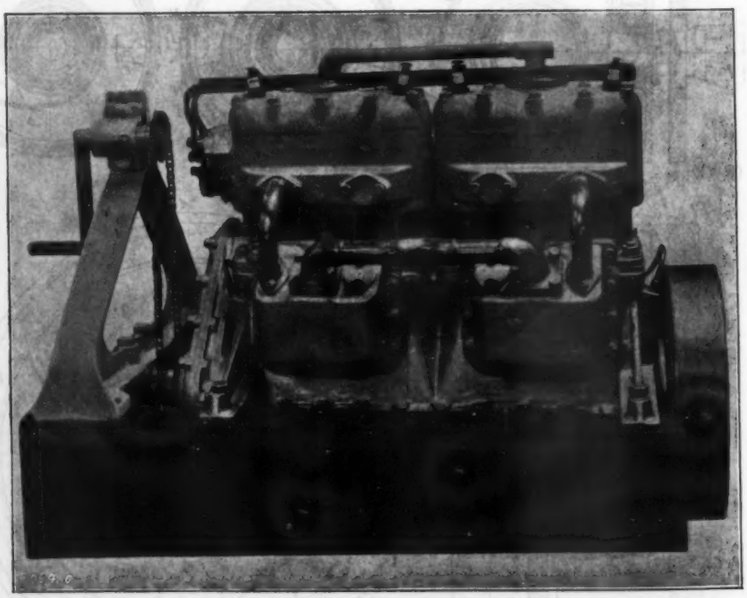
The nose end of each pawl, as in the previous case, is fitted with two hardened rollers, one of which engages in the slot while the other is engaged by the cam of the spring case. The width of the slot in the back plate is such that when this slot is in the position where the balance weight of the pawl will have the greatest tendency to engage the nose of the pawl, the engagement will take place up to a speed of 80 r.p.m. The slot may be arranged in a position where the balance weight has less effect and the action of the starter may be regulated in

this way. It may be arranged to cut out of action at a speed as low as 30 r.p.m. The cutting down of the action of the starter to such a low speed as this is particularly useful in the case of horizontally-opposed two-cylinder engines in which the magneto is arranged to run at half engine speed. In the ordinary way the starter is arranged to cut out at a speed of 60 r.p.m. As the engine speed increases, the centrifugal action of the balance weights on the pawls is sufficient to throw the pawls entirely out of action, and the starter becomes a rigid coupling









locked by the spring as in the case of the non-automatic starter. The automatic starter is particularly recommended for use in conjunction with electric starters and for small high-speed engines.

The Record Engineering Company, Limited, also show a 15-kw. emergency ship-lighting set driven by a direct-coupled "Silent Record" petrol paraffin engine. Other engines of this type are to be seen on the stand, one being sectioned to show the peculiar design. We illustrate in Fig. 45, annexed, a single crank Record engine, as the construction has many points of interest. It is of the two-stroke, single-acting type, with a pump to charge the working cylinders, so that the use of the crank chamber as a compression space is entirely avoided. The two working pistons B B, move together in parallel cylinders which have a combustion chamber common to both. Around one cylinder is a ring of ports H, through which the charge is admitted. Around the other cylinder is a ring of ports G, through which the exhaust takes place. The main object of having two working cylinders is to ensure complete scavenging. The two working pistons are fixed to the top of another piston A, which acts as a pump, and this latter piston is extended to form a cylindrical crosshead C which cuts off all communication with the crank chamber. The crosshead also relieves the working cylinders and the pump cylinder from all side pressure due to the connecting rod.

To understand the cycle of operations, it will be assumed that the pistons are in the position shown in Fig. 45, and that the charge has just been fired. The pistons will travel downward and compress the charge under piston A, in the passage J and around the ports H, to a few pounds pressure. As the pistons B, B approach the bottom of their stroke, the exhaust ports G are uncovered and allow the burnt gases to escape. As the pistons continue their descent, the inlet ports H are uncovered and the slightly compressed charge of fresh mixture is admitted. This passes up the cylinder, sweeps out the combustion space and fills the other cylinder, but no appreciable amount escapes through the exhaust ports as a measured quantity only is admitted. When the up-stroke takes place the valve E rises and puts the pump cylinder into communication with the carburettor by means of the port K, the incoming mixture being admitted through the port L.

The arrangement in the case of multi-cylinder engines (see Figs. 46 to 48) is somewhat different, although the principle employed is the same. In these the top side of the pump piston A is used to compress the mixture, which is delivered to the working cylinders belonging to the next crank. With this explanation the working cycle will be understood from the description of that of the single crank engine just dealt with, as corresponding details are similarly lettered. It will be noted that a single valve controls both cylinders. The Record engines are constructed to work with either petrol, paraffin, town gas or suction gas, and are made in standard sizes from 1½ b.h.p. to 250 b.h.p., for electric lighting sets and for land and marine purposes generally.

An interesting and attractively arranged display of some of their various testing machines is made by Messrs. W. and T. Avery, Limited, of Soho Foundry, Birmingham. We illustrate three examples of these. The first, shown in Fig. 49 on page 439, is a machine intended for a line of work with which we are not very closely concerned, but is none the less likely to prove of general interest. The machine is intended for testing the compression of golf balls, and forms a ready means of checking the tightness of winding of the core, and so maintaining uniformity of output in the factory. The curves given in Fig. 50 illustrate the compression and recovery of golf balls in the machine, curves A relating to a tightly-wound ball, and curve B to one wound much slacker. The machine compresses the ball, and the scale indicates the deflection in

Figs. 45 to 48. Internal Combustion Engines: The Record Engineering Company, Limited, Tutbury, Burton-on-Trent.

$\frac{1}{100}$ in. on a vernier. The load may be carried up to 155 lb. The arrangement of the steelyard and the details of the machine, which are simple, will be clear from the figure.

The machine shown in Fig. 51 is one designed for balancing the two ends of small connecting rods simultaneously. The machine determines how heavy or light each end is in comparison with a standard rod. When corrections have been made, the centre of gravity of all rods becomes similarly placed relative to the ends. No attention need be paid to the deadweight of the rod, because after correction, this automatically becomes the same for all rods, and is, of course, the sum of the two readings from the two weighing systems. In operation,

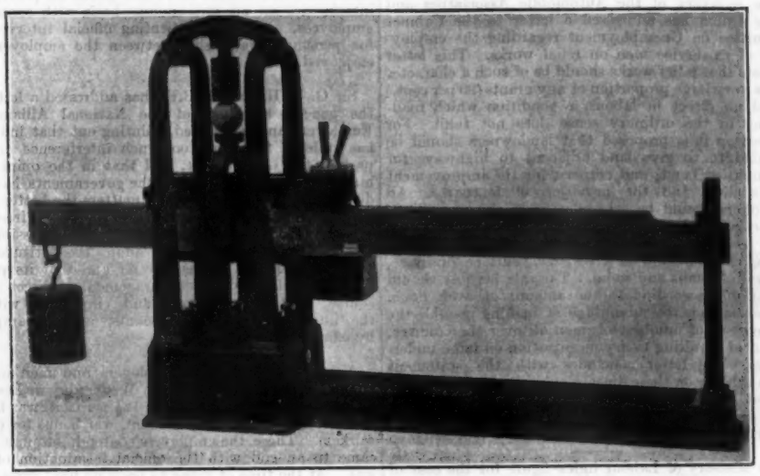


FIG 49 AND 50. MACHINE FOR TESTING GOLF BALLS. MESSRS. W. AND T. AVERY, LIMITED, BIRMINGHAM.

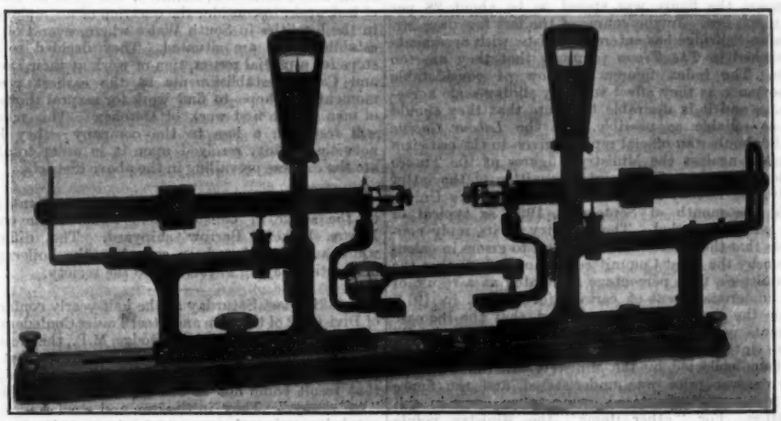


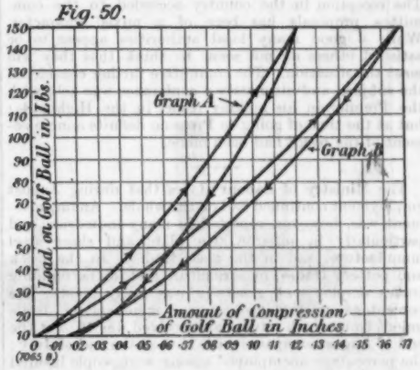
FIG. 51, MACHINE FOR BALANCING CONNECTING RODS: MESSRS. W. AND T. AVERY, LIMITED, BIRMINGHAM.

the standard rod is placed in the machine and balanced by means of the poise weights. The other rods then follow, and material is removed as required to effect a balance. The two steelyards are graduated up to 32 oz. and 64 oz. respectively, and the indicators are marked 1 oz. plus or minus. The left-hand system is movable along the bed to accommodate different lengths of rod, ranging from 7 in. to 16 in. centres. The other piece of apparatus shown in Fig. 52 is a device for proving Brinell hardness testing machines. As the Brinell test employs a definite load of 3,000 kg. it is of great importance to ensure that all machines really give this load. The proving apparatus consists of a portable steelyard which can be placed on the working table of any Brinell machine so that its accuracy can be checked by deadweights.

One of the classes of engineering material which is best represented in the exhibition is that concerned with the cutting and welding of metals either electrically or with an oxy-acetylene jet. The exhibits are about equally divided between the two types of appliances. The oxy-acetylene apparatus shown by Messrs. The Davis-Bournonville Company, of Jersey City, New Jersey, U.S.A., we need do no more than mention as we have dealt with this firm's products very fully in recent issues. All engineers interested in oxy-acetylene work should make a point of seeing the very interesting machines which this firm has on view. Demonstrations of oxy-acetylene welding and cutting are daily carried out at the exhibition by Messrs. Allen-Liversedge, Limited, of 106, Victoria-street, S.W. 1, and Messrs. Carbic, Limited, of 51, Holborn Viaduct, E.C. 1. These firms are well known in connection with this class of work and show various types of cutting and welding equipment, acetylene generators, flare lamps, &c. Material of the same class is also shown by The Thorn and Hoddle Acetylene Company, Limited, of 151, Victoria-street, S.W. 1, while their well-known specialities are exhibited by the British Oxygen Company, Limited, of Elverton-street, Westminster, S.W. 1. This company has recently acquired large engineering works at Edmonton and it is hoped that complete transference of their manufacture of metal cutters, blow pipes, &c., to the new works will have been effected by the end of the year. The company has recently also equipped a research laboratory at their Wembley works for investigation work in connection with industrial and rare gases.

Among the electric welding exhibits, Messrs. Alloy Welding Processes, Limited, of 14-16, Cockspur-street, S.W. 1, show a light and compact self-contained petrol-driven arc-welding set and also a motor generator set, which has been designed specially to meet the requirements of tramway engineers. The firm also shows a new type of alternating-current welding plant in which a maximum voltage of 50 only is used, thus eliminating danger from shock. The weight of the machine is 3¼ cwt. complete. Messrs. Alloy Welding Processes also show examples of their well-known coated electrodes which have been referred to more than once in our columns in the past. Electric arc-welding plants are also shown by The Premier

Fig. 50.



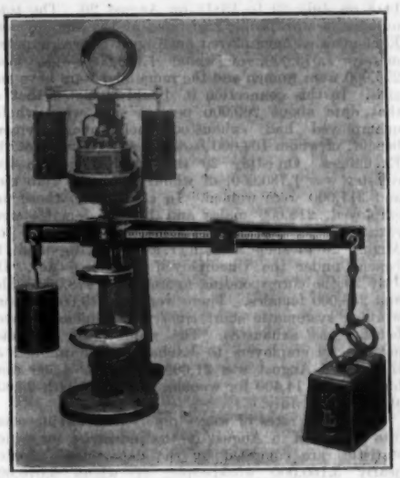


FIG. 52. APPARATUS FOR PROVING BRINELL MACHINES: MESSRS. W. AND T. AVERY, LIMITED, BIRMINGHAM.

Electric Welding Company, Limited, of Bank Buildings, St. James's-street, S.W. 1. The plants are of the single-operator type, one being driven by a 10-h.p. internal-combustion engine and the other by a 7½-h.p. electric motor. These machines require no series resistances in the welding circuit.

An exhibit is also made by the British Arc Welding Company, Limited, of Glengall-road, Millwall, E. 14. This company carries on a purely welding business and has carried out some very large repairs. They have a number of depots throughout the country, mostly in the ports. Their stand contains a number of examples of welding work, among which is a welded pressure vessel, 12¾ in. external diameter, and made from ⅜ in. ship plate which has withstood a pressure of 4,500 lb. per square inch. Electric welding is also represented by the stands of Messrs. Buckley, Saunders and Co., Limited, of 8, Princes-street, Westminster, S.W. 1, and the A.1 Manufacturing Company, of Industry Works, Sunbridge-road, Bradford. These firms both make extensive exhibits and show various forms of spot, butt and seam-welding machines.

(To be continued.)

INDUSTRIAL NOTES.

THE Cabinet Committee on Unemployment issued a statement after a meeting on Friday last of their scheme for assisting public authorities. These proposals include grants equal to 50 per cent. of the interest and sinking fund charges on loans raised by local authorities for approved non-revenue producing relief works which would not otherwise have been proceeded with, and actively commenced before January, 1922, for a period of one half of the term of the loan, subject to a maximum of 15 years. Preference will be given to projects giving direct employment to ex-service men. In the case of revenue producing works grants will be made in approved cases equivalent to 50 per cent. of the interest on loans raised for a period of not less than 10 years; these interest grants will be paid for a period of five years. The reception in the country accorded to the committee proposals has been of a mixed character. While a good many local authorities appear to be satisfied others do not seem to think that they will meet the situation. The committee further considered the subject, and ultimately a conference was held with the Premier in his holiday resort in the Highlands; but at the time of going to Press no definite announcement of the result had been made.

The Ministry of Labour states that during August employment continued bad on the whole. An improvement was, however, reported in many industries, and particularly in pig-iron, tin plate and sheet steel manufacture, and in the glass trades. In the brick and pottery trades, in agriculture and in the building trades employment generally was fairly good. The percentage unemployed among members of trade unions from which returns are received was 16·5 at the end of August compared with 16·7 at the end of July; the percentage unemployed among workpeople insured under the Unemployment Insurance Act fell from 14·8 on July 29 to 13·15 on August 26. The total number of workpeople registered at the Employment Exchanges as unemployed on August 26 was approximately 1,573,000, of whom 1,190,000 were men, 275,000 were women and the remainder were boys and girls. In this connection it should be noted that at that date about 209,000 persons who were wholly unemployed had exhausted their unemployment benefit, of whom 104,000 had ceased to register at the Exchanges. On July 29 the number on the live register was 1,780,000, of whom 1,351,000 were men and 317,000 were women. In addition to those unemployed, 218,600 males and 189,200 females were registered as working systematic short time on August 26 in such a manner as to entitle them to benefit under the Unemployed Insurance Act. On July 29 the corresponding figures were 278,000 males and 256,000 females. There were also 13,600 persons working systematic short time whose unemployment benefit was exhausted. The number of vacancies notified by employers to Exchanges and unfilled at the end of August was 21,000, of which 4,500 were for men and 14,400 for women, compared with 25,000 at the end of July.

Changes in rates of wages reported as having come into operation in August in the industries for which statistics are compiled by the department affected nearly 3,160,000 workpeople, of whom 3,070,000 sustained decreases, while nearly 90,000 received increases. The net effect of all the changes was a reduction in weekly full-time wages of about 690,000*l.* The principal groups of workpeople affected by reductions included building trade operatives, whose wages were reduced by 1*d.* per hour in most of the towns in Great Britain; coal miners, for whom there was a further decrease in most of the coalfields of 6*d.* per shift in the case of those 16 years of age and over, and of 3*d.* per shift in the case of those under 16; men employed in the engineering and various metal trades, in which the reductions amounted to 3*s.* per week for time-workers and 7½ per cent. for piece-workers; and dock labourers, whose wages were reduced by 2*s.* per day. Other important reductions affected workpeople in the heavy chemical and other trades and those employed by tramway undertakings. The increases affected chiefly men employed on civil engineering construction works. Since the beginning of 1921, changes in rates of wages reported to the department have resulted in a net reduction of over 3,550,000*l.* in the weekly wages of over 6,000,000 workpeople, and a net increase of about 73,000*l.* in the wages of 320,000.

The number of trade disputes involving stoppages of work reported to the department as beginning in August was 62. In addition, 43 disputes which began before August were still in progress at the beginning of that month. The total number of workpeople involved in all disputes in progress at any time in August (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 26,000, as compared with 1,127,000 in the previous month, and 86,000 in August, 1920. The magnitude of the figure for July was due, of course, to the national stoppage in the coal-mining industry, which remained unsettled until the beginning of July. The estimated aggregate duration of all disputes during August was over 200,000 working days, as compared with 6,300,000 days in July, 1921, and with nearly 900,000 days in August, 1920. The estimated aggregate duration of all the 477 disputes reported during the first eight months of the present year was approximately 84,000,000 working days. The total number of workpeople involved in these disputes was approximately 1,680,000. In the corresponding period of 1920 the number of disputes reported was 1,367, involving approximately 690,000 workpeople, and resulting in an aggregate loss of about 8,300,000 working days.

The secretary of the Automobile Association and Motor Union has addressed a letter to the Cabinet Committee on Unemployment regarding the employment of ex-service men on relief works. This letter suggests that relief works should be of such a character that a very large proportion of any grants (90 per cent.) should go direct in labour, a condition which road-making in the ordinary sense does not fulfil. For this reason it is proposed that landowners should be appealed to to give land adjacent to highways for widenings at bends and corners, for the improvement of visibility, and the provision of footpaths. All such offers should be scheduled by highway authorities acting with the Ministry of Transport, and their value assessed. The work would cover setting back fences, clearing land of trees, &c., surface drainage, removal of banks and so on. The rate per day should be variable according to the amount of work done. The scheme has the advantage of making possible the employment of numbers of men all over the country, instead of requiring their concentration on large undertakings. The letter concludes with the statement that a scheme on these lines would receive the wholehearted co-operation of the Automobile Association. Little else could surely have been expected for a plan so obviously proposed for the benefit of motorists.

The Ministry of Labour index figure for the cost of living at the beginning of September was about 120 per cent. above pre-war cost, and compared with 122 per cent. for August 2. It will be remembered that the Ministry's figures were disputed at the recent Trades Union Congress held at Cardiff, on which occasion the figure was stated to be about 28 per cent. too low. In the course of the last few days Mr. Gordon Selfridge has entered the lists, with arguments published in *The Times* to prove that they are too high. The index figures are now of considerable importance as they affect so many sliding scale agreements, and it is desirable therefore that they should be as reliable as possible. In the *Labour Gazette* for September an official reply is given to the criticism levelled against the Ministry's figures at the Trades Union Congress. The Joint Committee of the latter body, the Labour Party and the Co-operative Union, took the month of September, 1920, as typical of the post-war period. The Ministry in its reply contends that the difference found is due to errors in calculation by the Joint Committee. Thus it finds that the committee's final percentage is inflated as a result of the under-statement of certain food prices in 1914, while the committee also assumed that the increase in rents permissible under the Act of 1920 had fully come into operation—a conclusion invalidated by evidence collected by the Ministry. In coal and fuel the pre-war price was under-stated, and the figure for the group over-stated owing to an error in calculation. For "other items" the Ministry points out that the committee's comparison for the two periods has been made by them between differently constituted and non-comparable groups.

In a recent letter to *The Times* Sir Vincent Caillard supports the view lately expressed in the same columns by Sir William J. Noble, that we can only get away from the present unsatisfactory conditions by educating the country on the real factors controlling the economic situation. There is no doubt that the persistent propaganda of the socialistic section of the community has influenced, possibly sub-consciously, a good many of the workers, merely by reason of the fact that it has been allowed to go practically undisputed for so many years. Efforts at counter action have been taken, it is true, but they have lacked cohesion and therefore have been wanting in effect. Sir Vincent draws attention to the fact that a commendable endeavour is now being made by a body known as National Propaganda, with offices at No. 3B, Dean's-yard, Westminster, to co-ordinate and regulate this necessary educational work of exposing the fallacies underlying Socialist economics. Concentration of effort and sustained co-operation are, of course, likely to be far more effective than isolated endeavour can ever be. Financial support is needed.

The strongest point Mr. Macnamara made in his speech on Monday last on the working of the Trades Boards Act, was that not once had there been anything approaching a serious strike in any industry covered by a trade board. Mr. Macnamara was addressing the Grocers' Federation when he made this claim for the boards, but though he had a good deal to say in their defence, he also admitted that past experience had shown that they might be greatly improved, as they had been found too inelastic to meet varying local conditions. With the object of seeing how improvements may be introduced the Minister of Labour is appointing a committee of which Lord Cave will act as chairman. The composition of the Committee ought to secure the fullest confidence. We hope the committee will at least find some means for preventing interference on an uneconomic basis with contented employees, and for substituting official intervention for personal relationship between the employer and employed.

Sir G. B. Hunter, K.B.E., has addressed a letter to the general secretary of the National Alliance of Employers and Employed, pointing out that industry has suffered from far too much interference on the part of the Government, and that in the opinion of himself and others the less the governments have to do with industrial and labour matters the better; the need is not for more legislation but for greater freedom. We hope the National Alliance, with all its possibilities for good, will not definitely adopt the attitude imputed to it in Sir George's letter and that its policy may be marked by the encouragement of direct intercourse between employers and employed, without the intervention of governments, and unhampered by official regulations.

A joint conference of employers and men in the engineering trades was held on Wednesday in London, to consider the abolition of the 12½ per cent. war bonus for time workers, and 7½ per cent. war bonus for piece-workers. These, the employers contend, automatically came to an end with the official termination of the war. At the time of going to press no final agreement has been reached, but negotiations were proceeding amicably.

A special meeting of the directors of Messrs. Guest, Keen and Nettlefolds, Limited, was held at the end of last week, to consider the question of unemployment in the localities in South Wales where several of their establishments are situated. They decided to take steps for a partial resumption of work at their Dowlais and Cardiff establishments at the earliest possible moment, and hope to find work for several thousands of men by the first week of October. This measure will result in a loss to the company; they have, notwithstanding, resolved upon it in order to alleviate the distress prevailing in the above districts.

We refer in the leading article in our present issue to the strike of boiler makers which broke out at Messrs. Vickers' Barrow shipyard. The difficulty which arose has since been solved by the boilermaker in question paying his arrears to the society.

Speaking last Saturday at the half-yearly conference of Division 2 of the Iron and Steel Trades Confederation, held at Darlington, Mr. John Hodge, M.P., the president of the Confederation, expressed the hope that the present bad time would speedily come to an end, but that result could not be brought about by a policy of "ca' canny." They, in the iron and steel trades, did not believe that there could be increased output by a man doing half what he had formerly been in the habit of doing. The co-ordination proposed by the Joint Committee of the Trade Union Congress and the Executive of the Council of the Labour Party was discussed. Mr. Hodge, supporting the scheme, said the trade union movement had been blamed for not coming to the aid of the miners in the late dispute, but he felt that no union should be asked to take part in a strike unless it had been previously consulted. In a great national crisis like the mining dispute, the whole labour movement should have been consulted. Trade unions existed for industrial purposes, not for political purposes, and he did not think their movement could succeed by a general policy of striking for political ends.

In the September issue of the *Labour Gazette* we read that "following on the termination of the shipjoiners' dispute several yards were reopened; the joiners' resumption was also responsible for increased activity on the Tees, holidays being curtailed." Also "the dispute involving joiners and carpenters in shipyards throughout Great Britain, which began on December 1, 1920, was settled during August, a com-

OIL-CARRYING STEAMER "SAN FELIX" FOR THE EAGLE OIL TRANSPORT LINE.

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, AT THE WALKER YARD, NEWCASTLE-ON-TYNE.

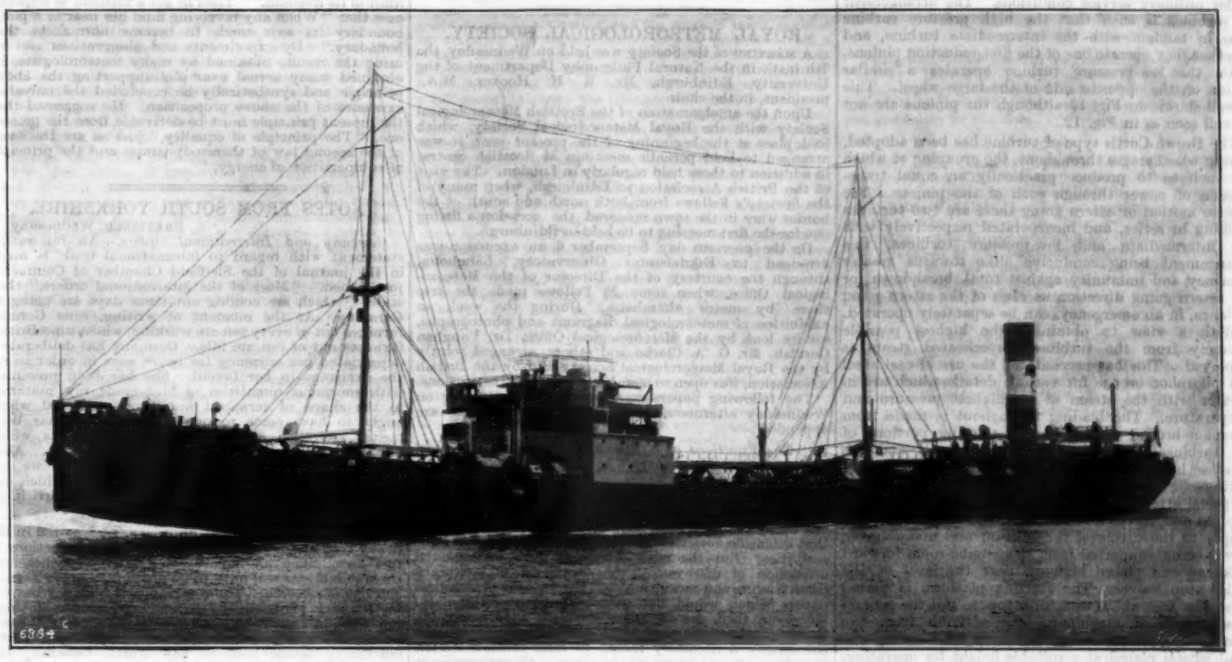


FIG. 1. THE VESSEL ON TRIAL.

promise being reached." It is a great pity that a compromise could not have been reached in this dispute in a few days instead of in about eight or nine months, since this strike has resulted in an enormous loss to the country. A few weeks ago we visited a Continental yard, in which the woodwork on a British-built ship was being carried out, owing to the strike in question. The ship joiners at that yard and on that particular British ship were working 11 hours at a stretch, and expressed their satisfaction at being able to do so, adding that "the more they worked the more they earned." That was, of course, to their advantage; but, where, it may be asked, does the internationalism one hears so much about, come in? The much-vaunted brotherhood of labour, which is supposed to extend beyond national boundaries, is actually merely empty talk dished up by British socialist leaders to gull their following. "Internationalism," we were told on the occasion referred to, "is an article for export to the United Kingdom." It is certainly difficult to find enthusiasm for it abroad, however much it may be preached at home.

THE OIL CARRYING SHIP "SAN FELIX."

WE reproduce on the two-page Plate accompanying this issue full constructional detail drawings of this vessel, which is built on the Isherwood system and is a good example of the type. The S.S. San Felix was built at the Walker Yard of Sir W. G. Armstrong, Whitworth and Co., Limited, for the Eagle Oil Transport Company. The vessel was designed by Sir W. G. Armstrong, Whitworth and Co., Limited, and has been constructed under the personal supervision of Mr. T. McClellan, their superintending engineer, and his colleague, Captain Cox.

The principal dimensions of the San Felix are:—

	Ft.	In.
Length overall	547	0
Length between perpendiculars ...	530	0
Breadth, extreme	69	4
Breadth, moulded	69	0
Depth, moulded to shelter deck ...	42	3
Height from main to shelter decks ...	15	0
Load draught (summer)	30	9¼
Corresponding deadweight (about) ...	18,500	tons
Speed on trial	11¼	knots

The vessel, as shown on the photographic view on this page and in the longitudinal section, Fig. 2, on the two-page Plate, is of the shelter-deck type with a straight stem and elliptical stern. She is framed on the Isherwood system and has been built under the special survey and to the requirements of the highest 100 A.1 Class of Lloyd's Register. In common with most oil tankers the vessel is built with "open bottom," except in the way of the machinery spaces and right forward, where a deep tank is fitted. The details of construction are clearly shown in Figs. 7 to 11, on the two-page Plate, and no further reference is necessary.

Dealing with the general lay-out of the vessel, as shown on the deck plans, Figs. 4 to 6 on the two-page Plate, the first fifth of the length from aft is allocated to the propelling machinery and auxiliaries, the steering gear, and accommodation of the entire complement, excepting deck officers. Adjacent to the boiler room are the fuel oil tanks, with a cofferdam completely separating this portion of the vessel from the oil cargo. Three oil tanks come next, with pump room separating them from the next group, containing five tanks. Here a second cofferdam is placed, so that different varieties of oil cargo may be carried in each group with complete immunity from risk of mixing. A group of two tanks succeeded by the second pump room, two further tanks and cofferdam completes the length utilised for bulk carriage of oil. Forward of the cofferdam is placed a second group of bunker oil tanks, and a large general cargo hold, with a fuel oil pump room pocketed in one wing. Below the cargo hold, as shown in Fig. 2, is a deep tank, available for either ballast water or reserve fuel oil, whilst the usual peak ballast tank and stores fill the fore end. Each cargo tank referred to above is divided into two by the centre line longitudinal bulkhead (Fig. 6). Above the main deck the tanks contract to the width of the expansion trunks, and the spaces on either side form the summer tanks. These tanks extend over each group of main tanks, there being one tank each side over the after group, two each side over the midship group and one each side over each forward group. In all the cargo space is divided into 34 tanks.

Every tank is provided with an oiltight hatch, 6 ft. by 4 ft., through which the cargo may be filled, and which, in the case of the side tanks, fulfils also the purpose of an expansion trunk. Filling may equally be carried out through the general pipe lines, which are connected to a pair of pumps in each pump room, the pumps having a duty of 300 tons per hour apiece. The system for handling the cargo is arranged so that four different varieties of oil may be dealt with simultaneously, and consists of two 10-in. mains, all fore and aft on top of the floors, one 8-in. main through either series of side tanks, and two 8-in. mains on the shelter deck from counter to foremast.

Each 10-in. main is connected to each main tank by an 8-in. suction with large boot—that is to say every tank has two such suctions fitted, and may be filled or emptied through either port or starboard mains. The side tanks are connected to the 8-in. mains without duplication by 6-in. suctions, the mains being connected in way of the pump rooms to the main cross-connection and also an amidships outlet. Each deck line has one outlet over the stern, four amidships above the after pump room, and two forward. In addition, four 6-in. ships side connections are provided for loading oil from barges alongside. All pipe lines are of mild steel lap-welded tube, and are fitted with numerous expansion joints, including one in every tank. All valves are of cast iron, sluice pattern, and directly actuated from the shelter deck by wrought-iron rods devoid of gearing.

The main lines are divided in each pump room by a section valve, and two cross-connections pass oil into or out of either part. Each pump can draw from both the cross-connections and discharge to the deck lines or to the other cross-connection. In effect, the cross-connections form a ring main, with the forward and after parts of the main lines independently connected thereto, and with branches to the side tanks, barge suctions, sea and bilge.

The bunker line, of 8-in. diameter, is placed on deck and connects the forward group of bunkers with that aft. Loading may be carried out by direct intakes or by a connection to the main loading pipes. Special barge suctions are provided forward through which the fuel pump in the fore hold may load either the forward or after group. A ballast pump is placed in the same recess for dealing with ballast water forward.

Numerous auxiliary services are fitted in connection with the oil tanks. Heating of the cargo and bunker oil has been extensively provided for by distinct systems. Gas freeing is effected through a 4-in. main to which every cargo oil hatch has a 3-in. connection and sluice. The main is taken up each pole mast for a height of 40 ft., and terminates in a goose neck. Gas ejection is provided for by a system of 3-in. pipes connected at each group of tanks and at the pump rooms to Korting ejectors. Sounding caps are arranged at the top of the down-takes to each tank. Steaming-out pipes are fitted to every tank, the steam for these and for ejection being taken from the winch range. Scales are arranged inside each expansion trunk, visible from sight glasses or plugs in the hatch covers. A wire span is arranged above the lines of hatches, with all fittings for hoisting wind sails for ventilation of the tanks.

The propelling machinery, constructed and installed on board by the Wallsend Slipway and Engineering

Company, Limited, of Wallsend-on-Tyne, consists of three turbines working in series and driving the propeller shafting through compound or double-reduction gearing. Two views of the turbine installation are given on page 444. This turbine machinery has been designed to develop about 4,300 shaft horse-power, under ordinary service conditions. The arrangement of turbines is such that the high pressure turbine runs in tandem with the intermediate turbine, and together they operate one of the first-reduction pinions, while the low-pressure turbine operates a similar pinion on the opposite side of the large wheel. This is well shown on Fig. 13 although the pinions are not so well seen as in Fig. 12.

The Brown-Curtis type of turbine has been adopted, having wheel stages throughout, the grouping of which are such as to produce practically an equal transmission of power through each of the pinions. For reverse motion or astern going there are two turbines working in series, and incorporated respectively with the intermediate and low-pressure turbines, this arrangement being conducive alike towards greater efficiency and immunity against total breakdown for the astern going direction as each of the astern-going turbines, in an emergency, can be separately operated.

With a view to obtaining the highest possible economy from the turbines, superheated steam is employed. This has necessitated the use of cast steel and phosphor bronze for various details which are in contact with the steam at its highest pressure and temperature. The blading throughout is made from phosphor-bronze material. The rotating portions of the turbines comprising the stage wheels and the spindles have been made entirely from ingot steel forgings.

Special attention has been given to the arrangement of pipes and valves for the main and emergency steam supply to the turbines, the shut-off and manœuvring valves being supported from the engine-room forward bulkhead and placed high up near the level of the boiler stop valves. The starting platform is placed some few feet above the tank top to suit the general arrangement of machinery, the spindles from the manœuvring valves being led down and having the hand wheels placed at a suitable height for operating. The revolution counter and pressure gauges are grouped on a stand placed adjacent to the starting position.

The thrust shaft, main line shafting and propeller shaft are of forged ingot steel. The propeller is of the built type, with boss of cast-iron, to which are attached four blades of manganese-bronze. The thrust block is of the Michell oil-film type, the details of the design having been based upon experience obtained with this type of block in other classes of work. The condenser is of the Weir Uniflux type, designed to secure 27½ in. of vacuum in ordinary service conditions with the temperature of sea water at 85 deg. F. In the arrangement of machinery it was found possible to place the condenser at a low level, and at the same time quite close to the low-pressure turbine, which simplifies the drainage problem and also does away with the usual overhead exhaust connection. So far as auxiliaries are concerned the usual Wallsend practice is followed.

The boilers are of the multitubular single-ended type, five in number, 15 ft. 3 in. outside diameter and 12 ft. long. There are three furnaces to each boiler, arranged for burning fuel oil on the Wallsend-Howden system. The boilers are constructed for a working pressure of 220 lb. per square inch. The boilers are designed to work under Howden's forced draught. The installation for burning liquid fuel is arranged on the pressure principle, and is in accordance with the Wallsend-Howden usual practice.

The whole of the machinery has been constructed under the supervision of Mr. Thomas McLellan, the superintendent for the owners.

The ship lighting set is of 80-kw. output and supplies current for about 250 lights, various fans and a Marconi installation. The steering engine operates direct on a toothed quadrant attached to the tiller, to which are attached also emergency steering chains actuated by an auxiliary steering gear in the same compartment. Control is by telemotor gear from the navigating positions.

A large after deck-house (Figs. 2 and 3) encloses the machinery casings and accommodation for the whole of the complement excepting the executive officers. On the starboard side is a series of spacious single-berth cabins for the chief and other engineers, together with mess room, bath and lavatory. On the port side the sailors and firemen are housed in four-berth cabins, with mess rooms, galleys, &c., adjacent. This deck-house is fully enclosed at each end; on top are placed boys' and stewards' cabins and the lifeboats; from the aforesaid the fore and aft gangway leads to the bridge-house and to the forecastle. The bridge contains the officers' cabins, mess room and dining saloon, on the level of the gangway, with all necessary domestic offices. On the deck above is placed a fine suite of four staterooms for directors or passengers, with lounge, bath, &c. The deck over forms the navigating bridge, and has a compact deck-house containing the wheel-house and chart room, wireless telegraphy house and operators' cabins, captain's cabin with anti-chamber and bath. The roof of this house forms the standard compass platform.

ROYAL METEOROLOGICAL SOCIETY.

A MEETING of the Society was held on Wednesday, the 7th inst., in the Natural Philosophy Department of the University, Edinburgh, Mr. R. H. Hooker, M.A., president, in the chair.

Upon the amalgamation of the Scottish Meteorological Society with the Royal Meteorological Society, which took place at the beginning of the present year, it was arranged to hold periodic meetings at Scottish centres in addition to those held regularly in London. The visit of the British Association to Edinburgh, when many of the Society's Fellows from both north and south of the border were in the town rendered the occasion a fitting one for the first meeting to be held in Edinburgh.

On the previous day, September 6, an excursion was arranged to Eskdalemuir Observatory, Langholm, through the courtesy of the Director of the Meteorological Office, when some 20 Fellows made the trip there by motor charabanc. During the week an exhibition of meteorological diagrams and photographs, kindly lent by the Meteorological Office, Dr. Vaughan Cornish, Mr. G. A. Clarke and others, arranged jointly by the Royal Meteorological Society and by the British Association, was open to members of the two Institutions.

The following papers were read at the meeting on Wednesday afternoon, and abstracts of the same are appended:—

1. "*The Functions of a Scientific Society, with Special Reference to Meteorology*," by R. H. HOOKER, M.A., President.

The increase in Government institutions undertaking original scientific investigations, of a kind formerly carried out by individuals, may have led some persons to think that scientific societies had been shorn of some of their activities. But the main functions of a society—the discussion of discoveries, the formation of a library (both lending and consulting) and the printing of technical papers which would not pay to publish—all remain. Moreover, there are far more scientific experts outside Government service than in it, and even the latter find the society a necessary means of inter-communication in order to keep abreast of the times. Governments at present do little to encourage amateur research, and the spread of science among the greatest number of people is one of the most important objects of the society, which forms a natural meeting ground, and is open to practically everyone interested. Meetings for discussion, and a certain "clubbiness" are of the greatest value in stimulating research. The recent amalgamation of the Royal and Scottish Meteorological Societies might at first appear to curtail the opportunities of Scottish Fellows for meeting their colleagues; but the present session in Edinburgh was intended to be the forerunner of others. But, besides this, there seemed to be no adequate reason why Scottish Fellows should not continue to hold meetings in Edinburgh as heretofore; indeed, Mr. Hooker considered it would be an advantage if local meetings were held at any centre where there were a sufficient number of Fellows within reach.

2. "*Meteorology in Medicine; with Special Reference to the Occurrences of Malaria in Scotland*," by ANGUS M. MACDONALD, O.B.E., M.D.

After brief reference to primitive conceptions and superstitions and a general consideration of the meteorological associations with disease hitherto studied, the author asserts that the fundamental meteorological factor influencing biological reactions is temperature. This influence is universal in its application to organic life in its beginnings and continuity, and has specific implication in the production of disease. The *rôle* of temperature in the manufacture of diseases due to the parasitic protozoa is exemplified in a consideration of the temperature limitations of the development of the sexual phase of the plasmodin of malaria in the anophelin mosquito. In illustration, the history of the various temperature conditions that have prevailed since early in the eighteenth century indicate the possibility of the occasional occurrence of malaria. Actual recorded outbreaks were shown to coincide with abnormal high temperature over several months in consecutive years. Wars have been the main factor in the introduction of malarial infection, which is powerless to establish the disease epidemic in Scotland, and will produce an outbreak only when importation in large volume coincides with a mean temperature of 60 deg. F. continued over a period—an event of rare occurrence.

3. "*Some Notes on Meteorology in War Time*," by C. J. P. CAVE, M.A., J.P.

4. "*On the Diurnal Variation of Atmospheric Pressure at Castle O'er and Eskdalemuir Observatory, Dumfriesshire*," by Dr. A. CRICHTON MITCHELL, F.R.S.E., Superintendent, Eskdalemuir Observatory.

The hourly values of atmospheric pressure recorded at Eskdalemuir Observatory during the ten years 1911–20 have recently been reduced, and the results are being prepared for publication. Meanwhile a comparison of these results with those obtained by Dr. C. Chree from the Castle O'er barograph records during 1902–08 show very considerable differences, although the stations are close together. The paper details these differences and attempts to explain them as being due to unsuitable exposure of the Castle O'er instrument and to its imperfect temperature compensation.

5. "*The Natural Tendency towards Symmetry of Motion and its Application as a Principle in Meteorology*," by Dr. S. FUJIWHARA, of the Central Meteorological Observatory, Tokio.

The author put forward the principle of tendency towards symmetry in such a form that "any revolving system in nature, tends towards symmetry within the limit of its freedom." Then he got a theorem as a special case that "When any revolving fluid lies near to a plane boundary its axis tends to become normal to that boundary." By experiments and observations and by using the results obtained by many meteorologists, he obtained many actual examples supporting the above principle and synthetically he concluded the universal existence of the above proposition. He suggested that the present principle must be derivable from the greater one, "The principle of equality," just as are the cases of the second law of thermodynamics and the principle of equipartition of energy."

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Germany and International Orders.—An interesting statement with regard to international trade is made in the journal of the Sheffield Chamber of Commerce just issued. "Most of the international orders," they state, "which are coming out these days are going to Germany. At the moment of writing, nine German furnaces out of every ten are working, whilst nine British furnaces out of ten are idle. Germany has deliberately depreciated her currency far below ours in order to rig the exchange in her favour. She has been presented with enormous quantities of high-grade raw material, in the shape of scrapped munitions—material which ought to have come to our side—and this has been melted, re-rolled and converted into products which are to-day sweeping our goods off the markets. Also, Germany is aided by earnest labour, whilst we are hindered by 'ca' canny.' This is an aspect which our workers must realise and meet in the right spirit if we are to regain any prosperity."

Iron and Steel.—A slight improvement is noted in the heavy steel trade of Sheffield. The recent reductions in fuel have given an impetus to certain branches, but these reductions will have to go much further ere normal activity is restored. There certainly is a steady inquiry for foundry pig-iron, and a fair demand for castings, but most of the orders received by Sheffield steel firms relate to repairs and renewals of home plant and machinery rather than to new work. Generally the production of iron and steel will remain light until fuel costs are sufficiently low to justify the big buyers coming into the market. Our export trade is slack, not only on account of the exchange rates being so heavily against us, but owing to the fact that many of the countries with whom we did a brisk pre-war business have now no money to spend. Shipbuilding is at a low ebb and there is little prospect of improvement so long as freights remain at the present unprofitable level. This, of course, refers to mercantile tonnage. A bright spot on the immediate horizon is found in the anticipated battleship orders which must benefit Sheffield and Sheffield firms to a great extent. The placing of four battle cruisers of the "Hood" type, to whichever yards they are allotted, must result in marked activity over a large industrial area. Their requirements are enormous, and no district will experience greater benefit than South Yorkshire. Railway orders are still to a great extent withheld, and the dropping of various large housing schemes has had a notable effect on the demand for iron and steel castings, girders and building tools. The lighter trades of the district improve slowly. Christmas orders are light, though the Colonies are inquiring more freely. Business in high-speed tools is healthy, but most other tools are quiet, being hard hit by German competition. The crucible steel trade continues in a depressed condition. Inquiries for files, saws and joiners' tools, in which a fair business has been doing, have slackened.

South Yorkshire Coal Trade.—Owing to the large stocks of small fuels on hand many of the pits have had to cut down work to three and four days a week. This has had a healthy effect on the steam coal market, and has given large coal and cobbles a decidedly firmer tone. The consumption, however, is no greater, though an anticipated improvement in general trade gives reason to hope that a considerable increase in the demand will shortly take place. The export trade is dull. Heavy reserves at the works and large floating stocks awaiting unloading are having their effect on business in gas fuel, which has fallen off to a substantial extent. Small fuel and stacks are almost a drug on the market, large quantities having been disposed of from 5*s.* to 9*s.* per ton. In house coal buyers are still holding off for lower rates, and less business is passing than is usual at this period. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 32*s.* to 33*s.*; Derbyshire small nuts, 29*s.* to 30*s.*; Yorkshire hards, 34*s.* to 35*s.*; Derbyshire hards, 33*s.* to 34*s.*; rough slacks, 17*s.* to 18*s.*; nutty, 16*s.* to 17*s.*; smalls, 5*s.* 10*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Quietness continues to characterise Cleveland pig-iron, and whilst No. 3 G.M.B. is still exceedingly scarce, demand for the ruling quality is on but a limited scale, and home customers will not pay more than 125*s.* for immediate supplies. The home

price of No. 3 for October delivery is not more than 120*s.* There is practically no foreign trade passing in this quality, but any inquiries from abroad elicit quotations of about 5*s.* above home rates. The inferior grades of Cleveland pig-iron are quite plentiful and difficult to dispose of. No. 4 foundry is offered very freely at 119*s.*, and makers would very readily sell from their large stocks at 117*s.* 6*d.* for No. 4 forge, and mottled, and 115*s.* for white iron.

Hematite.—With increased output, supply of hematite has become more than ample, and makers are keen sellers. Whilst some producers endeavour to maintain prices at the figures that have been named for some little time past others make no secret of their efforts to secure orders by granting substantial concessions. Nos. 1, 2 and 3 East Coast brands can now be bought at 130*s.* both for home use and for export.

Foreign Ore.—The price of best rubio has been given at 28*s.*, but values of imported ores really cannot be fixed, for not only is business entirely suspended, but effort to renew buying and selling, on anything like an extensive scale, cannot be expected, until stocks have been very materially reduced, and deliveries against old contracts, long overdue for completion, have been fairly well taken up.

Coke.—Durham blast-furnace coke keeps in the neighbourhood of 35*s.* delivered, which is at least 5*s.* above what local consumers are prepared to pay, and consequently business is almost at a standstill.

Manufactured Iron and Steel.—Holding the view that further fall in values is at hand, finished iron and steel customers are purchasing to meet pressing needs only. Iron bar makers have lowered their prices 2*l.* Export business can be done at substantially below the following, which are among the principal quotations for home purposes:—Common iron bars, 14*l.*; marked bars, 18*l.*; iron rivets, 18*l.*; steel billets, 10*l.* 10*s.* to 11*l.*; steel boiler plates, 19*l.*; steel ship, bridge and tank plates, steel hoops, tees, and heavy steel rails, all 14*l.*; steel angles and joists, 13*l.* 10*s.*; rounds and squares, 13*l.*; flats, 14*l.*; fishplates and sleepers, 19*l.*; black sheets, 17*l.*; and corrugated galvanised sheets, 20*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Though business on the coal market remains quiet cargo exports foreign continue to expand. Shipments in the past week established a record for the year, amounting to 419,000 tons. They are, however, 183,000 tons less than the quantity dealt with in the corresponding period of 1913, so that we are still a long way behind the normal capacity of the docks. Many complaints have been made of late respecting the inadequacy of loading facilities, caused partly by the restricted working hours of the trimmers and partly by the fact that a number of tips are not in commission or under repairs. These defects are, however, receiving attention, and it is expected that before long there will be an improvement in this respect, for three new hoists, with a capacity of shipping 500 tons to 600 tons per hour, are nearing completion at the Cardiff docks, while repairs to a railway viaduct, which has practically put out of commission five tips, will shortly be finished. Shippers generally hold the view that the old system of continuous working at the docks should be restored instead of two continuous shifts of 8 hours each as at present, but the men say that they can deal with all the coal available and that what is required is more engine power, and that appliances, now idle, should be brought into operation. So far as the coal market is concerned large coals of practically all descriptions are in excessive supply, with prices irregular and on balance lower. Smalls, however, are a relatively strong market, for with the restart of a number of coke ovens, iron and steel and tin-plate works, the supplies available for export have been considerably reduced. In fact, some colliery salesmen have no small for disposal, and in many cases they are refusing to sell small without large. Best and second-class Admiralty large coals are obtainable from 30*s.* to 32*s.*, best Monmouthshire large from 27*s.* 6*d.* to 28*s.* 6*d.*, best dry large round 30*s.*, and No. 2 Rhondda large from 25*s.* to 27*s.* 6*d.* Best steam smalls are steady at 19*s.*, second smalls round 17*s.*, ordinaries 15*s.*, and inferiors from 9*s.* up. The French Navy are inviting f.o.b. tenders for 60,000 tons of Admiralty large coal, and a considerable quantity of fuel-making smalls, delivery over the last three months of the year. The Norwegian State Railways have placed an order for 15,000 tons of double-screened best Admiralty large with Scotch exporters at 32*s.* 10½*d.* f.o.b., which, after allowing 2*s.* 6*d.* per ton for screening, leaves 30*s.* 4½*d.* for the coal.

Colliery Deal.—Messrs. Guest, Keen and Nettlefolds, Limited, owners of iron and steel works and collieries, have made an offer to purchase the whole of the share capital of the Gwaun-cae-Gurwen Colliery Company, Limited, which owns two pits near Swansea, producing the best qualities of anthracite coal. Guest, Keen, offer one 1*l.* ordinary share for one 1*l.* ordinary share of Gwaun-cae-Gurwen, and one 5 per cent. free of tax, second cumulative preference share of 1*l.* for one 7 per cent. Gwaun-cae-Gurwen preference share of 1*l.* The Gwaun-cae-Gurwen share capital consists of 229,770*l.* in 1*l.* ordinary shares and 16,640*l.* in 7 per cent. preference shares.

Iron and Steel Trades.—Though costs of production are still above selling prices an optimistic feeling prevails among operators, for with Continental prices stiffening and makers booked up, it is anticipated that there will be a revival in the demand for Welsh plates. More works have been restarted, and prices are steady on the basis of 21*s.* to 22*s.* for standard boxes.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The outlook in the Scottish steel trade is far from encouraging, and some freely state that it is very black indeed. The depression which has been all too general during this year shows no sign of lifting, and unemployment in the trade is at the present time very high. The plant running might be taken as about a quarter, and the work is being divided up amongst the regular employees to give them all a share. Inquiries are still coming in, but little business is resulting, and a considerable tonnage will require to be booked before long or most of the works will come to a full stop. Already the Glengarnock Steel Works, now under control of Messrs. David Colville and Sons, Limited, Motherwell, has been closed down after a big effort having been made to keep it running, but all to no purpose. Foreign buyers are almost out of the market meantime, and home buyers are placing very little business locally because of the inducements offered by Continental producers. The rate of exchange has a great deal to do with this, and the net result is that there is very much less unemployment on the Continent than there is in this country. The difference in prices is much too great, and the local steel makers are quite aware of this and are constantly considering the matter in the hope of bringing them nearer. For the present, however, little can be done so long as costs continue so high. Makers of steel sheets are managing to pick up some odd lots both on home and export account, but mills are only running intermittently.

Scottish Malleable Iron Trade.—The malleable iron works in the West of Scotland are not in a very healthy condition, as regards business just now, and shifts are almost at a minimum. There is very little work being booked, and orders on hand are quickly turned out. The competition from the Continent continues very keen, and unless consumers stipulate for locally-manufactured bars the foreigner secures the business. With the view of improving the present state of things at the works, the Scottish malleable bar iron makers have made another cut of 2*l.* per ton in prices, and now quote "crown" bars at 14*l.* per ton, net, delivered Glasgow stations. This new figure is for the home trade only, and the export price is a matter of arrangement between buyer and seller. The new price is now only 5*s.* per ton more than half the top price of the year which was 27*l.* 10*s.* per ton.

Scottish Pig-Iron Trade.—Little change has taken place in the Scottish pig-iron trade of late, but a shade more business has been passing. Owing to the recent increase in the number of furnaces in blast there is more foundry iron available, and local consumers have been replenishing their stocks, but only to a moderate extent. Now that ironmasters are in a position to do something on export account it is to be hoped that shipowners will listen to the cry for lower freights, and thus encourage the local makers to regain even a part of their old foreign trade. Hematite iron is moving very slowly because of the poor state of affairs in the steel trade.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The first ordinary general meeting of the session of the Institution of Automobile Engineers will be held on Wednesday, October 12, at the Royal Society of Arts, John-street, Adelphi, at 8 p.m., when the president for the forthcoming session, Mr. George Watson, will deliver his presidential address, entitled "Industrial Standardisation." Application to attend the meeting should be made to the Secretary, 28, Victoria-street, S.W. 1. On October 5 the North of England Centre of the Institution will resume its activities when a meeting will be held in the Assembly Room, Education Offices, Salford, Manchester, at 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—A number of thoroughly practical papers have been arranged for the coming session of the Institution of Engineers and Shipbuilders in Scotland, of which Mr. Harold Yarrow, C.B.E., is this year the president. The internal-combustion engine, naturally occupies a prominent place, and engineers generally will look forward with considerable interest to the paper which the Engineer-in-Chief of the Navy is to read, on "Developments in Modern Diesel Engines." Another paper on the same subject, by Mr. A. D. Bruce, will deal with "Some Factors Limiting the Power of Diesel Engines." A further paper is to be considered, the author being Mr. Archibald Rennie, who is on the staff of the Scotts' Company at Greenock, where a long series of important tests have taken place of the Still engine and its suitability for marine propulsion. These will, no doubt, be completely dealt with by Mr. Rennie. The screw propeller is ever a source of interest to engineers and shipbuilders, and two papers, on this subject, are to be read, one by Mr. W. J. Duncan, B.Sc., on the "Design of Screw Propellers and the Analysis of Trial Results," and the other by Mr. Campbell Macmillan, B.Sc., on "Analysis of Propeller Performance." Mr. G. S. Baker, O.B.E., and Mr. G. H. Bottomley, as joint authors, will contribute a paper on the "Manœuvring of Ships," and we shall probably have one of those valuable contributions for which Mr. Baker and his staff at the Experimental Tank, at the National Physical Laboratory, are noted. The programme further includes papers on "Ball and Roller Bearings," "The Economic Proportions of Cargo Ships," "The Assessment of Harbour and Other Dues," together with papers on "The Double Bottom Construction of Ships," "A New Type of Gearing," "The Saving of Fuel by Utilising Exhaust Steam for Heating," and "Brittleness and Fatigue in Metals."

NOTICE OF MEETING.

FARADAY SOCIETY.—Wednesday, September 28, at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. General discussion on "Catalysis with Special Reference to Newer Theories of Chemical Art." Details will be found in a paragraph in our last issue (page 410 *ante*).

PERSONAL.—The Record Engineering Co., Limited, of Tutbury, Burton-on-Trent, inform us that they are prepared to grant a limited number of licences for the manufacture of the patent two-stroke engine which is the speciality of the firm.

UNIVERSITY COLLEGE, LONDON.—Mr. Albert E. Webb, B.Sc., A.M.Inst.C.E., has been appointed senior assistant in the Department of Civil and Mechanical Engineering at University College, London, in succession to Mr. H. P. Philpot, who resigned in July, on being appointed professor in the Finsbury Technical College. Mr. Webb was educated at the Manchester College of Technology, and has been for eleven years with Messrs. Vickers, Limited, Barrow-in-Furness, where he became assistant chief designer and chief draughtsman.

THE CERAMIC SOCIETY: REFRACTORY MATERIALS SECTION.—The Refractory Materials Section of the Ceramic Society will hold an autumn meeting in the hall of the Institution of Mechanical Engineers on October 6 and 7. Lieutenant-Colonel C. W. Thomas will preside. The programme for Thursday, October 6, includes the reading of papers, commencing at 10.30 a.m. The following are expected to be taken: "Refractory Materials of the London Basin," by Mr. H. Dewey; "The Marlow Gas-Fired Tunnel Oven," by Mr. J. H. Marlow; "A New Type of Tunnel Kiln, Oil Fired," by Mr. P. J. Woolf; "Aluminothermic Corundum as Refractory Materials," by Dr. A. Granger; "The Reversible Thermal Expansion of Silica," by Professor J. W. Cobb and Mr. H. S. Houldsworth; Symposium on Gas Firing. A dinner will be held at 7 p.m. On Friday, October 7, the general meeting will be held at 10 a.m. for the election of officers, &c. In the afternoon a visit will take place to the National Physical Laboratory, Teddington.

SOUTH WALES AND MONMOUTHSHIRE SCHOOL OF MINES.—We have received from this institution, which has schools at Treforest and Crumlin, a copy of the calendar for the ensuing session. The work, which commences on the 3rd prox., includes courses for colliery engineers, chemical engineers, colliery managers, chemical assistants, colliery mechanics and electricians, and mine surveyors. Full particulars of all these courses are given in the calendar, copies of which can be obtained from the Secretary, Mr. Hugh M. Ingledew, 4, Mount Stuart-square, Cardiff. It may, perhaps, be explained that the institution was established by the principal coalowners in the South Wales and Monmouthshire coalfields, and is maintained entirely at their expense for improving technological instruction in all branches of coal mining. The expenses are met by a levy of 0·1*d.* per ton output of the various subscribing collieries, the total output of which amounts to nearly 30,000,000 tons annually. The schools are open on equal terms to all students over 16 years of age, and particulars of the educational standard required for entry are given in the calendar.

THE DESTRUCTION OF THE NITROGEN-FIXATION PLANT AT OPPAU.—The works of the Badische Anilin-und Soda-Fabrik at Oppau, which were destroyed by explosions at 7.33 a.m. last Wednesday, were among those inspected by Allied commissioners in February, 1919, and have been characterised as one of the greatest technical achievements of all times. The works, only completed in 1913, were much enlarged during the war for the fixation of atmospheric nitrogen which is now chiefly converted into fertilisers. The capacity was recently estimated by the Nitrogen Products Committee at 250 metric tons per day. Lignite is gasified; the gas produced is catalytically converted into hydrogen and carbon dioxide; the CO_2 is removed by water under compression, the power being recovered by the use of Pelton wheels. Finally a mixture of hydrogen and nitrogen is catalytically converted into ammonia in bombs at a pressure of 200 atmospheres and a temperature of about 600 deg. C. There is danger of explosions in many of the stages of this complex Haber process which it took years to work out. The various reports so far available speak of explosions either in gasholders or in the stores of salts. The two theories may be compatible with one another. The most valuable product made on the works, nitrate of ammonium, is not an explosive in the ordinary sense, but would become an explosive under the powerful excitation of an initial explosion, and stores of thousands of tons of salts are mentioned, though they are not specified. The works were completely destroyed, though three of four tall chimneys were left intact—an odd fact. Oppau is situated near the left bank of the Rhine, a few miles below Ludwigshafen, opposite Mannheim on the right bank of the Rhine; these places and the neighbourhood for 20 miles round are said to have suffered. The number of killed and injured is said to exceed 2,000 out of a total of 3,000 workers on the premises. The cost of the Oppau works was estimated before the war at 15,000,000*l.*, and the indirect damage caused by the destruction of works of this importance will be very heavy.

DOUBLE-REDUCTION GEARED TURBINES FOR THE OIL-CARRYING S.S. "SAN FELIX."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 441.)

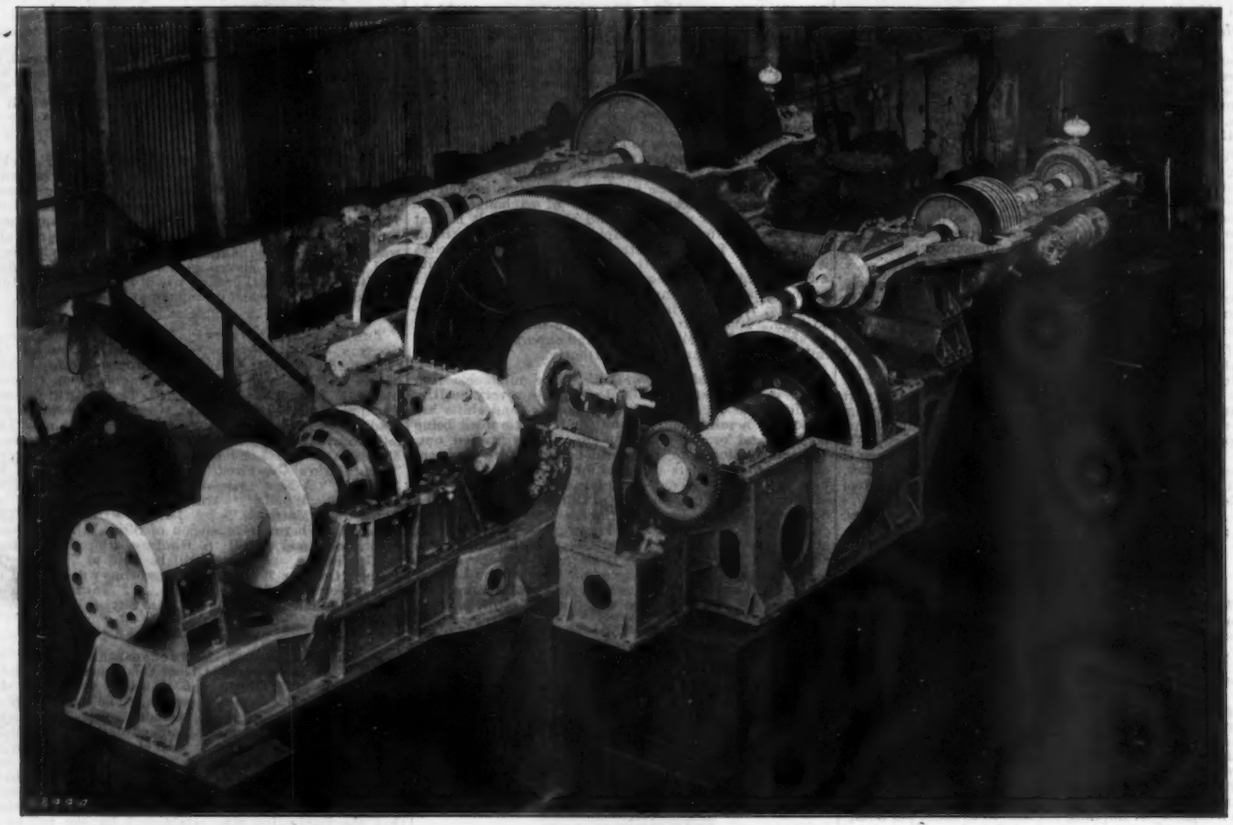


FIG. 12. TURBINES AND GEARING, LOOKING FORWARD.

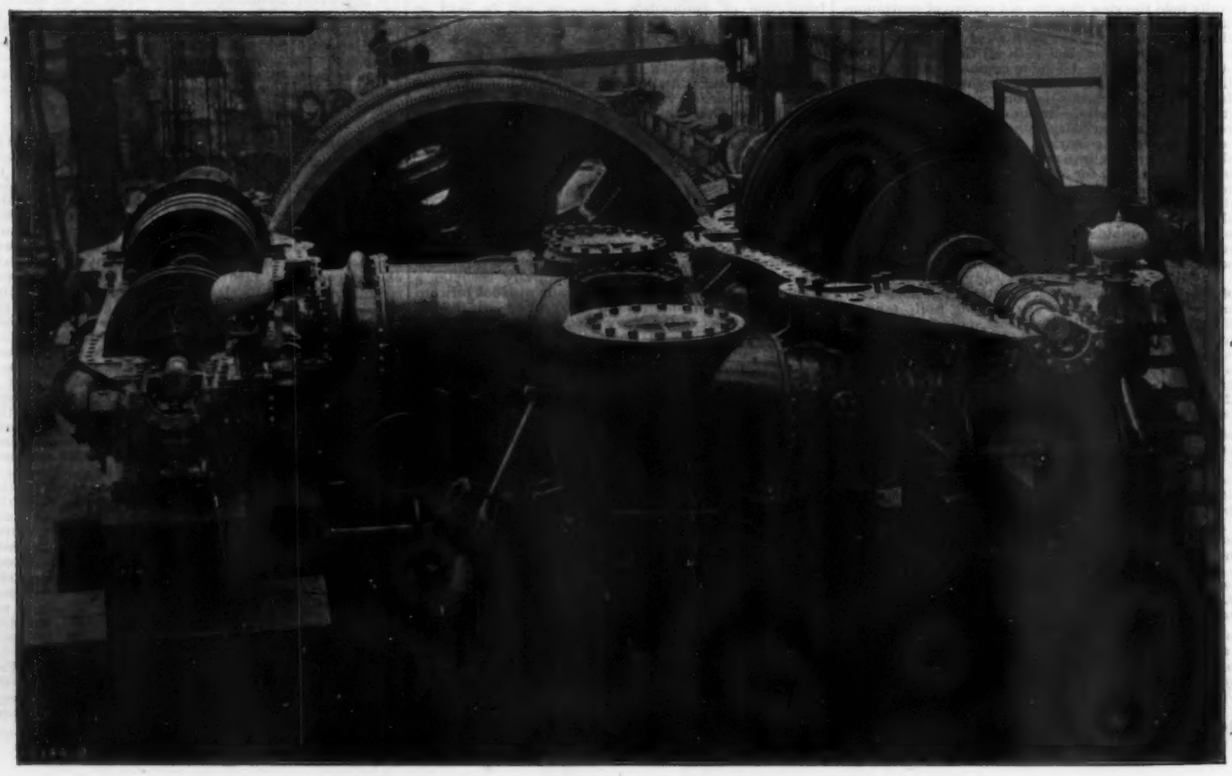


FIG. 13. VIEW OF TURBINES AND GEARING, LOOKING AFT.

THE TURBINE-DRIVEN OIL-CARRYING STEAMER "S FE

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AN LIMITE

(For Descrip Page 44

Fig. 3.

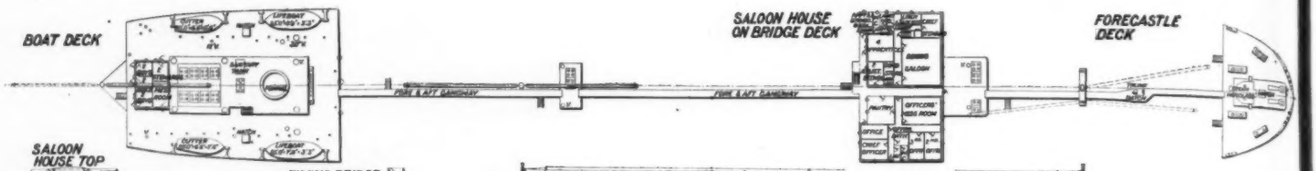
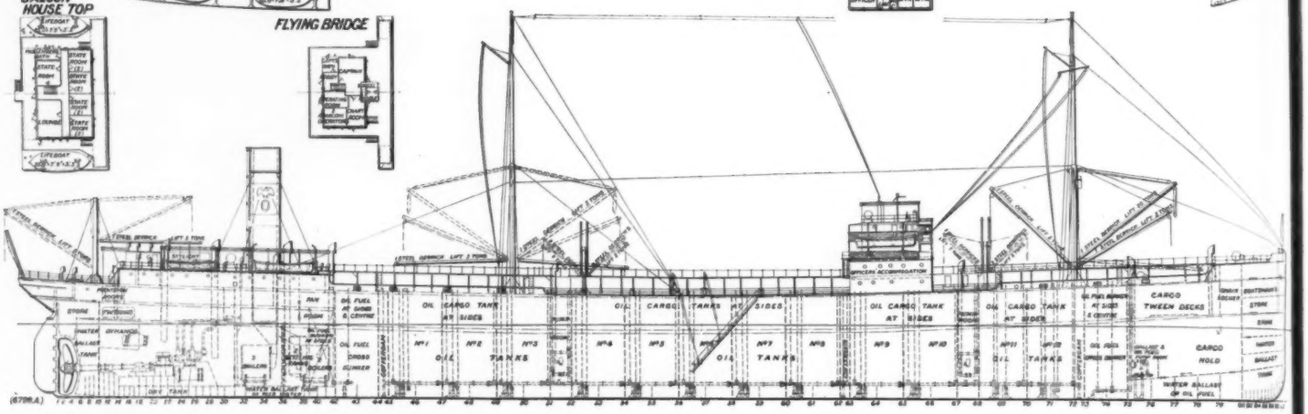


Fig. 2.



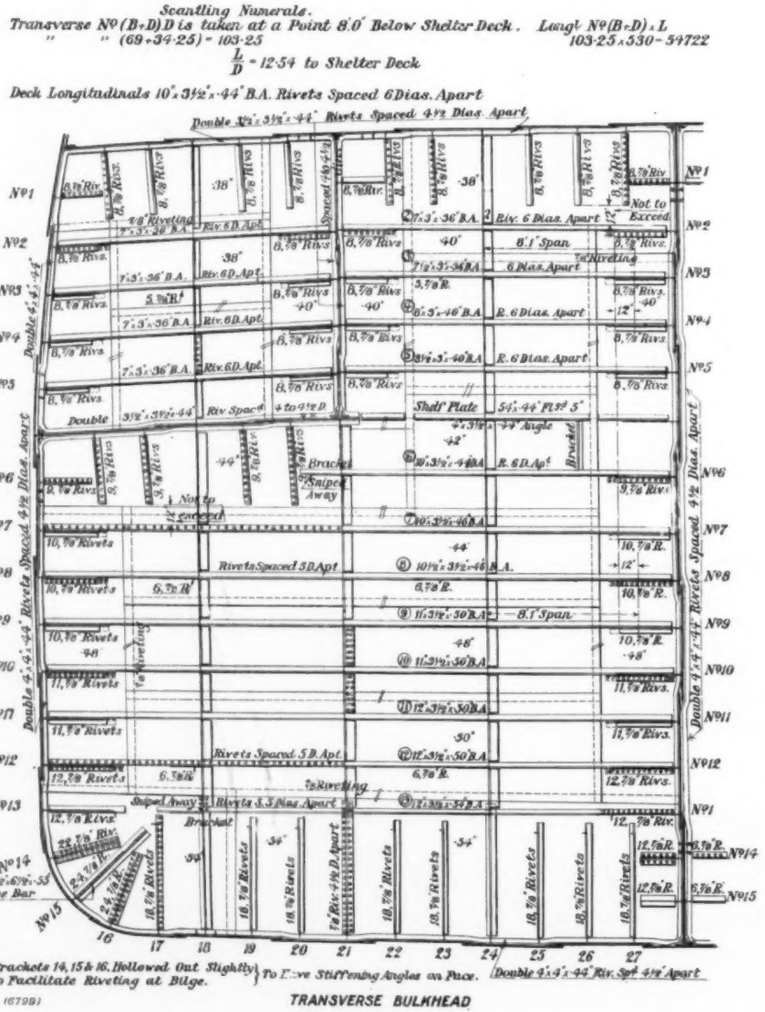

Scantling Numerals.
Transverse № (B+D)D is taken at a Point 8'0" Below Shelter Deck. Longl № (B+D)×L
(69+34·25) = 103·25 103·25×530 = 54722
L/D = 12·54 to Shelter Deck
Deck Longitudinals 10"×3½"×44" B.A. Rivets Spaced 6 Dias. Apart
Double ¾"×3½"×44" Rivets Spaced 4½ Dias. Apart
Double 4½"×4½"×44" Rivets Spaced 4½ Dias. Apart
Brackets 14, 15 & 16. Hollowed Out Slightly to Facilitate Riveting at Bilge.
To Five Stiffening Angles on Face.
Double 4½"×4½"×44" Rivs. Spd 4½" Apart
TRANSVERSE BULKHEAD

FIG. 7. DETAILS OF TRANSVERSE BULKHEAD.

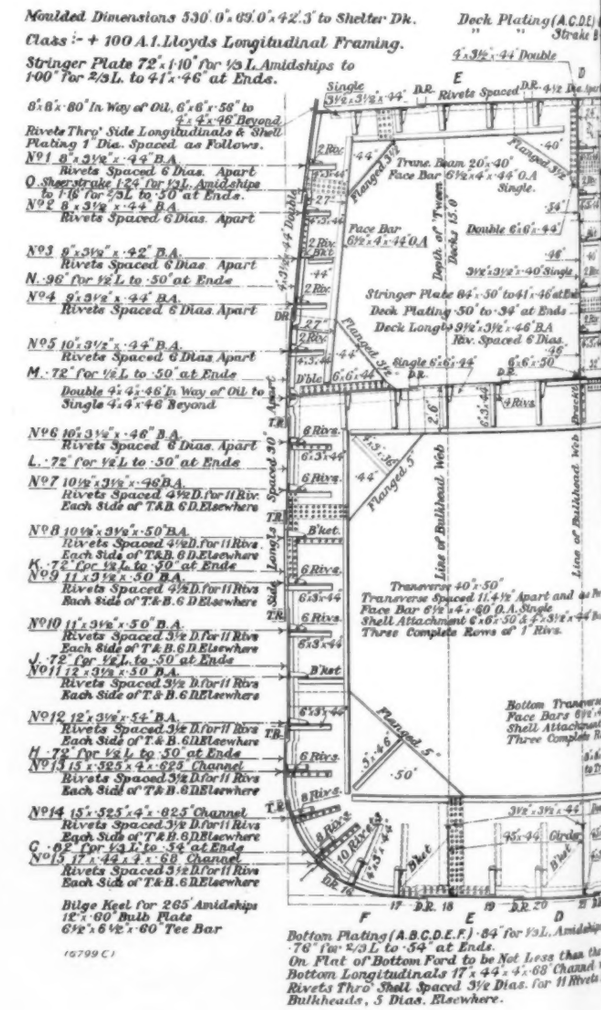

Moulded Dimensions 530'0"×69'0"×42.3' to Shelter Dk.
Class :- + 100 A.1. Lloyds Longitudinal Framing.
Stringer Plate 72"×·410" for ⅓ L Amidships to 1·00" for ⅔L. to 41"×·46" at Ends.
8"×8"×·80" In Way of Oil, 6"×6"×·58" to 4"×4"×·46" Beyond
Rivets Thro' Side Longitudinals & Shell Plating 1" Dia. Spaced as Follows.
№1 8"×3½"×·49" B.A.
Rivets Spaced 6" Dias. Apart
Q Sheer strake 1·24" for ⅓L. Amidships to 1·18" for ⅔L. to ·50" at Ends.
№2 8"×3½"×·44" B.A.
Rivets Spaced 6" Dias. Apart
№3 8"×3½"×·42" B.A.
Rivets Spaced 6" Dias. Apart
N. ·96" for ½L. to ·50" at Ends
№4 9"×3½"×·44" B.A.
Rivets Spaced 6" Dias. Apart
№5 10"×3½"×·44" B.A.
Rivets Spaced 6" Dias. Apart
M. ·72" for ½L. to ·50" at Ends
Double 4"×4"×·46" In Way of Oil to Single 4"×4"×·46" Beyond.
№6 10"×3½"×·46" B.A.
Rivets Spaced 6" Dias. Apart
L. ·72" for ½L. to ·50" at Ends
№7 10½"×3½"×·48" B.A.
Rivets Spaced 4½" D. for 11 Rivs. Each Side of T.& B. 6 D. Elsewhere
№8 10½"×3½"×·50" B.A.
Rivets Spaced 4½" D. for 11 Rivs. Each Side of T.& B. 6 D. Elsewhere
K. ·72" for ½L. to ·50" at Ends
№9 11"×3½"×·50" B.A.
Rivets Spaced 4½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
№10 11"×3½"×·50" B.A.
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
J. ·72" for ½L. to ·50" at Ends
№11 12"×3½"×·50" B.A.
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
№12 12"×3½"×·54" B.A.
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
H. ·72" for ½L. to ·50" at Ends
№13 15"×·525"×4"×·625" Channel
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
№14 15"×·525"×4"×·625" Channel
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
G. ·62" for ⅓L. to ·54" at Ends
№15 17"×·44"×4"×·68" Channel
Rivets Spaced 3½" D. for 11 Rivs Each Side of T.& B. 6 D. Elsewhere
Bilge Keel for 265' Amidships 12"×·60" Bulb Plate 6½"×6½"×·60" Tee Bar
Deck Plating (A.C.D.E.) ·84" for ⅓L. Amidships ·76" for ½L. to ·54" at Ends.
On Flat of Bottom Ford to be Not Less than
Bottom Longitudinals 17"×44"×4"×·68" Channel
Rivets Thro' Shell Spaced 3½" Dias. for 11 Rivets
Bulkheads, 5 Dias. Elsewhere.

FIG. 8. MIDSHIP

Page 44
Fig. 4.
Fig. 5.
Fig. 6

FELIX" FOR THE EAGLE OIL TRANSPORT LINE.

LIMITED, AT THE WALKER YARD, NEWCASTLE-ON-TYNE.

Page 441.)

Fig. 4.

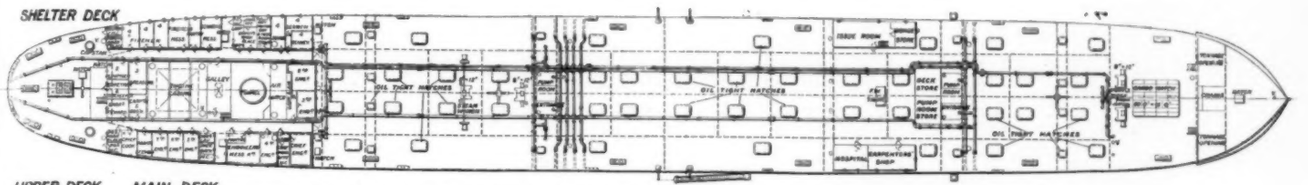


Fig. 5.

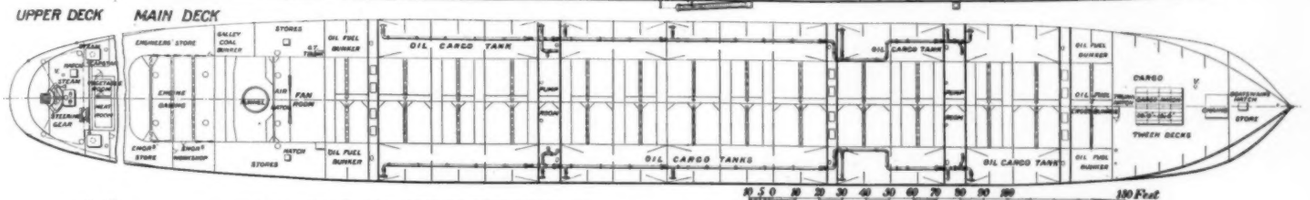
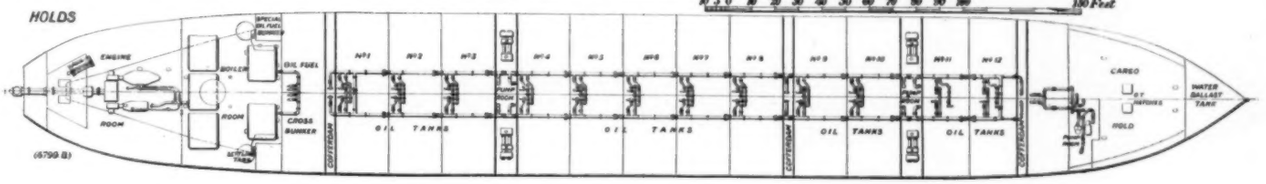


Fig. 6.



L Amidships to ·76" for 2/3L. to ·38" at Ends.

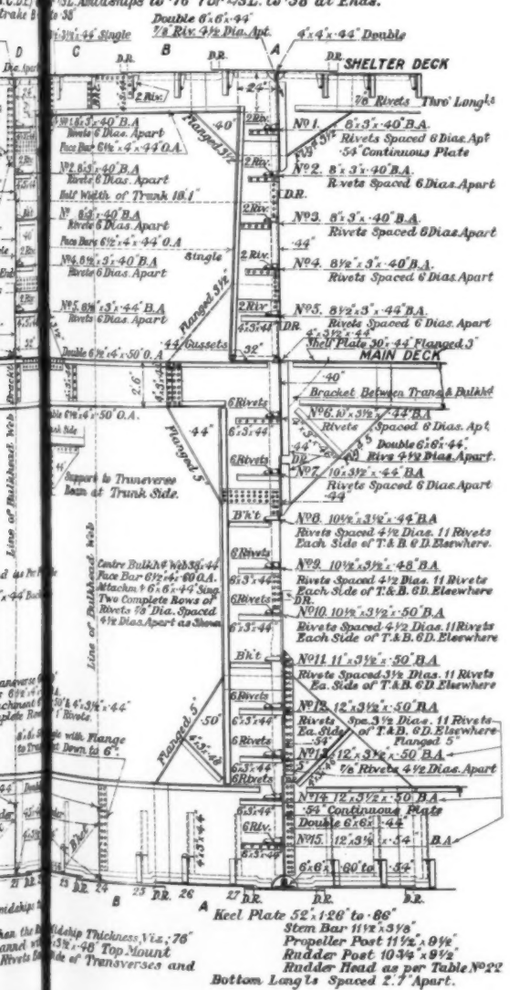

SHELTER DECK
MAIN DECK
Double 6'6"x·44"
7/8 Rivs 4½ Dias. Apt.
4"x4"x·44" Double
76 Rivets Thro' Longls
No 1. 8"x3"x·40" B.A.
Rivets Spaced 6 Dias. Apt
·54" Continuous Plate
No 2. 8"x3"x·40" B.A.
Rivets Spaced 6 Dias. Apart
No 3. 8"x3"x·40" B.A.
Rivets Spaced 6 Dias. Apart
No 4. 8½"x3"x·40" B.A.
Rivets Spaced 6 Dias. Apart
No 5. 8½"x3"x·44" B.A.
Rivets Spaced 6 Dias. Apart
Shelf Plate 30"x·44" Flanged 3"
Bracket Between Trans & Bulkhd
No 6. 10"x3½"x·44" B.A.
Rivets Spaced 6 Dias. Apt.
Double 6'6"x·44"
49 Rivs 4½ Dias. Apart.
No 7. 10"x3½"x·44" B.A.
Rivets Spaced 6 Dias. Apart
No 8. 10½"x3½"x·44" B.A.
Rivets Spaced 4½ Dias. 11 Rivets
Each Side of T. & B. 6 D. Elsewhere.
No 9. 10½"x3½"x·48" B.A.
Rivets Spaced 4½ Dias. 11 Rivets
Each Side of T. & B. 6 D. Elsewhere
No 10. 10½"x3½"x·50" B.A.
Rivets Spaced 4½ Dias. 11 Rivets
Each Side of T. & B. 6 D. Elsewhere
No 11. 11"x3½"x·50" B.A.
Rivets Spaced 3½ Dias. 11 Rivets
Ea. Side of T. & B. 6 D. Elsewhere
No 12. 12"x3½"x·50" B.A.
Rivets 5pa. 3½ Dias. 11 Rivets
Ea. Side of T. & B. 6 D. Elsewhere
·54"
No 13. 12"x3½"x·50" B.A.
7/8 Rivets 4½ Dias. Apart
No 14. 12"x3½"x·50" B.A.
·54" Continuous Plate
Double 6'6"x·44"
No 15. 12"x3½"x·54" B.A.
6'6"x·60" to ·54"
Keel Plate 52"x·128" to ·86"
Stem Bar 11½"x3⅛"
Propeller Post 11½"x8½"
Rudder Post 10¾"x8½"
Rudder Head as per Table No 22
Bottom Longls Spaced 2'7" Apart.

Fig. 9.

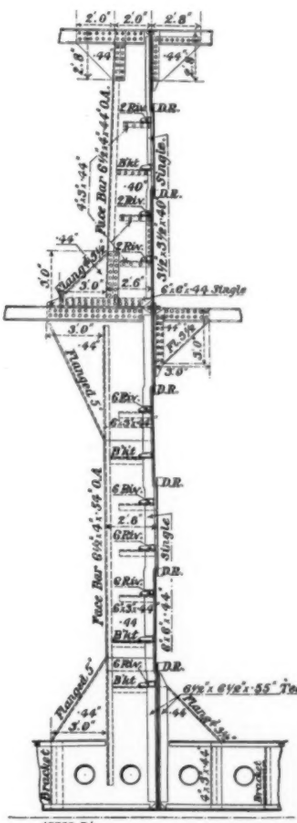


Fig. 10.

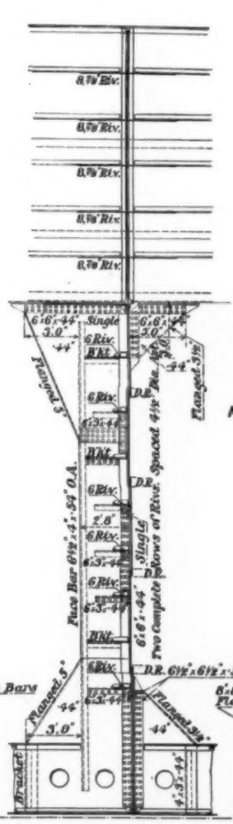
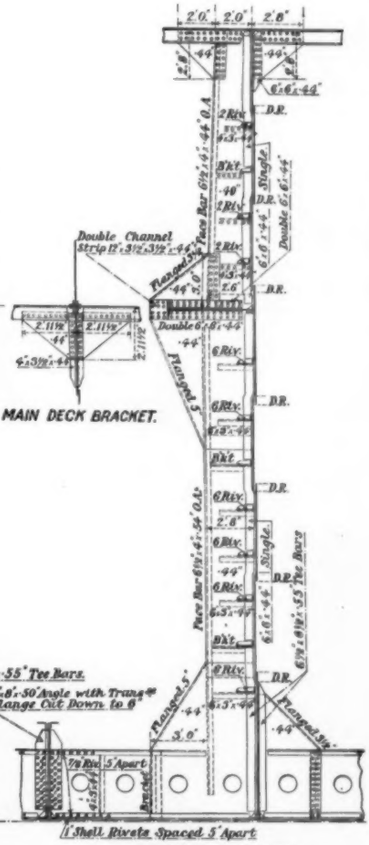

Face Bar 6½"x·44" O.A.
Flanged 5"
Flanged 3½"
Two Complete Rows of Rivets Spaced 4½ Dias. Apart
6½"x6½"x·55" Tee Bars
WEB 18'.1" OFF CENTRE.

Fig. 11.



FIGS. 9 TO 11. DETAILS OF WEBS.

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AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
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MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa) Ltd., 29 and 31, Long Street, Capetown.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

When foreign subscriptions are sent by Post Office Orders advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C.2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8393 GERRARD.

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With a Two-Page Plate of the TURBINE-DRIVEN OIL-CARRYING STEAMER "SAN FELIX" FOR THE EAGLE OIL TRANSPORT LINE.

ENGINEERING.

FRIDAY, SEPTEMBER 23, 1921.

THE ATTITUDE OF LABOUR.

PERHAPS the most remarkable feature in the debate on work and wages, which followed Mr. W. L. Hichens' recent address to the Economics Section of the British Association was the general failure to realise the extreme interest and, quite possibly, fundamental importance of the method of fixing wages, embodied in the recent coal settlement. Mr. Hichens indeed did refer to the scheme, but seemed little impressed by it.

The objection to all ordinary schemes of profit-sharing lies in the fact that at the best they are only applicable to undertakings already well established, whilst the industrial progress of the country is largely dependent on the possibility of a man of exceptional ability, being able to turn a small business into a large one by making high profits in the first place, and investing these profits in the business, instead of distributing them amongst his employés in the shape of bonuses and the like. A pioneer of the heavy electrical trades once informed us that after the first disheartening and costly pioneering difficulties were overcome, he was, for a short time, making goods for about 30*l.* which he was able to sell for 90*l.*, with the result that works which were started with three men were, in the course of five or six years, providing well-paid employment for 500. The abnormal profits gained during part of the period of development were due entirely to the capacity, courage and enterprise of the employer in question, and no fair claim could be sustained for their distribution amongst his workmen.

If the present tendency to strike continues, we must resign ourselves to abandoning our hardly-won industrial position. Only last week 1,000 boiler-makers went on strike at Barrow, because one of their members was in arrears with his subscription to their union. The firm knew nothing of the matter till the previous day, and had then at once entered into communication with the executive of the Boiler-Makers' Society. The men struck, however, without awaiting the result. Nearly a week later the man was reinstated upon payment of his arrears, and the strike ended. Surely this alone proves that the strike was quite unjustifiable.

As Sir Alfred Yarrow has pointed out in a recent issue of *The Times*, such strikes are fatally affecting the recovery of our foreign trade. The impossibility of fixing with reasonable accuracy dates of delivery is a most serious handicap to business. Another difficulty to which he refers is the widespread belief that reduction of output merely lowers the proprietors' profits, but benefits the men by making the work go further. Attempts, for the most part half-hearted, have been made to dispute the prevalence of such practices, but the evidence is too conclusive to be set aside. Indeed, during the war a trades union official was brought before the courts, and convicted, on the charge that he had fined a moulder heavily because the man had finished certain moulds in less than the "recognised time."

Questions of demarcation, again, are, as Sir Alfred points out, a cause of frequent trouble. Possibly a solution may be found along the lines of the arbitrators' award anent demarcation in the Chicago Building Trades. He held that in the future any job that can be done in less than 30 minutes may be done by any workmen, whether the job is or is not generally attributed to a particular craft. No doubt much greater freedom than this would be highly desirable, but even this minor concession would be of very substantial value. As matters stand, Sir Alfred states that in a shipyard no iron worker may fix a piece of wood, nor may a joiner apply a coat of paint, no matter how trivial the job may be.

A useful suggestion was made in Mr. Hichens' address, viz., that the term "civilised wage" should be substituted for "living wage," which has been defined by Mr. Clynes as a wage which should assure to the human being a condition of life equal to the expectations and tastes of a civilised population of this age. The natural interpretation of the term is, however, such a wage as will just enable the worker to exist and maintain his strength, and polemists, in arguing about such questions, are in the habit of alternating the significance of the term "living" to suit the immediate requirements of their argument. No such objection applies to the term "civilised wage," as whilst a workman must earn enough to permit him to exist, the degree of civilised comfort to which it is practicable for him to attain necessarily varies with circumstances.

Loose methods of expression are, however, common in "progressive" literature. In a recent letter to *The Times*, for instance, Mr. Lansbury objects to a society in which "one section of the nation lives on the labour of the rest." So long, however, as a nation does not kill off its aged and crippled, such a section must always exist, and such a condition of affairs is accordingly not necessarily inexpedient. Whether in any particular instance the forcible abolition of such a section would be to the ultimate advantage of the community is in any case a complicated question, which cannot be settled by *a priori* argument but only by experience.

In the discussion which followed Mr. Hichens' address, Mr. G. Hopkinson took up the somewhat doubtful position that there was no community of interests between employers engaged in the same industry. This view was very prevalent before the war, and was, we believe, a serious handicap to us in meeting foreign competition. That Mr. Hopkinson's view is not shared by all employers is demonstrated by the number of industrial research associations which have been organised, and in the pottery trade, at any rate, such organisations have proved conspicuously successful.

We agree with Sir Trevor Dawson, who, in his address at the opening of the Shipping, Engineering and Machinery Exhibition, held that the salvation of our industries will ultimately be found in the innate common sense of the vast majority of our population. It unfortunately happens, however, that although—as proved by our literature, scientific work and political and social development—our race yields pride of place to none in the matter of native intelligence, the trouble has ever been to persuade the average citizen to sufficiently exercise his powers of thought. When he does so use them he commonly arrives at wise decisions, but times of crisis apart, he is far too apt to let others do his thinking for him in all matters not immediately connected with his "daily darg." For example, a not unimportant section of the middle classes, in ante-war times, accorded the rôle of seer and prophet to Mr. Bernard Shaw. The bladder of this writer's reputation as a serious thinker was, however, soon pricked when the gravity of the issues raised by the war compelled these intellectual sluggards to ascertain facts for themselves, in place of accepting, as hitherto, Mr. Shaw's paradoxical perversions of them. In the same way large masses of workmen have been captivated by the followers of Karl Marx, who reasons as if wealth were a commodity self-created, and that the social and industrial problem was accordingly a question of its equable distribution, whilst in actual fact the question of distribution is of quite secondary importance as compared with that of creating the new wealth necessary to liquidate the burden left by our recent struggle for existence.

It is of considerable interest to examine into the credentials of the writers and speakers who claim to do the work man's thinking. In a recent address to the Œcumenical Methodist Conference, Mr. A. Henderson declared that, relatively speaking, the position of the "common people" of to-day was no better than that of their forbears before the age of energy was inaugurated by the magnificent inventions of James Watt. History, however, tells a different tale. Even without going back to the Middle Ages, or to countries where the seigneur dispensed the high, the low, and the middle justice to his unfortunate serfs, a reference to the literature of the 17th and 18th centuries is sufficient to disprove Mr. Henderson's plea. Of course, on the purely material side there is no question but that

the condition of the "common people" has improved not only absolutely but relatively to the well-to-do.

It mattered little to the wealthy man of the 18th century if every drop of water required in his household had to be fetched from a distant well, and the introduction of the modern system of water supply was accordingly relatively a much greater benefit to the "common people" than to him. Such instances could be multiplied indefinitely, and a reference to the literature of the two centuries in question proves that there has at the same time been an ever-increasing tendency to recognise that—to quote Mr. Henderson—"the worker is after all a man," and entitled to be treated as such.

Pepys, for instance, records that Sir William Coventry proposed to hire bravoes to slit the nose of some actor who had offended him, and relates that the watch got into trouble for daring to arrest two rowdy aristocrats who were creating a disturbance by running about the streets nearly naked. Even Jane Austen appears to be a little in awe of the great Mr. D'Arcy. Voters, again, were driven to the poll like cattle to vote for the nominee of their "betters," under the threat of ruin if refractory. Few indeed saw anything very reprehensible in such a procedure, but to-day the whole outlook on such matters has been fundamentally changed. If Mr. Henderson can so misread history as to claim that there has been no relative advance in such matters, it is not likely that he will prove a safe guide on social and economic questions, where the teachings of the past form the only reliable touchstone for testing the real worth of schemes for the reconstruction of society.

Mr. Philip Snowden, again, is another of those who have volunteered to do the workman's thinking for him. In a recent letter to *The Times* he states that in the generation in which Germany and America forged ahead, the wages of their workers and their hours of labour improved in larger measure than in this country. Even were the statement true it would prove nothing. In the matter of hours of labour, for example, we were long in front of both Germany and America. Where conditions are already good, an improvement of 10 per cent. may be more difficult to effect than one of 50 per cent. in bad conditions, and the failure to recognise this discounts any claim Mr. Snowden may make to be taken as a serious thinker on such matters. As for Mr. Ramsay Macdonald, it will be sufficient to recall that he attributed the war to a desire on the part of our Admiralty to make a practical test of their new guns and equipment generally. It is men of this kind who, like the Pharisees of old, have laid burdens on mankind grievous to be borne, and to the practical alleviation of which they will not lift one little finger. Having been largely responsible by their teachings for the present distressful conditions, none of them makes any practical proposals for their alleviation, but merely brings forward again schemes which past experience has repeatedly proved to be disastrous. That their proposed remedies have proved futile, wherever tried, affects their faith in them no more than was Dr. Sangrado's belief in the general efficacy of bleeding disturbed by the fatal results which occasioned the remonstrances of Gil Blas. The time seems opportune, however, for a reversal of policy, and for this an eloquent plea was made by Lord Weir in a recent address to the Incorporation of Hammermen at Glasgow.

THE BRITISH TRADE SHIP.

THE project of organising a floating exhibition of British goods which shall visit the chief ports of the world with the object of providing overseas buyers with tangible evidence of the nature and quality of the products of our factories, has now assumed a definite shape. With Earl Grey as chairman, Sir George B. Hunter, the chairman of Messrs. Swan, Hunter and Wigham Richardson, Limited, as vice-chairman, and a strong business directorate on which the Federation of British Industries is represented by its general secretary, a company has been incorporated under the name of British Trade Ship, Limited, for the purpose of carrying out the scheme on a scale worthy of the interests involved. A new vessel of 20,000 tons register, and suitable in all ways as an exhibition ship, is to be constructed, and it is intended that she shall leave the Thames on August 15, 1923, on a tour of some 42,288 miles, returning to London on February 7, 1925. The first port of call is to be Bahia, thence *via* Rio de Janeiro and Monte Video to Buenos Ayres. Crossing the South Atlantic, Cape Town and Durban will be visited and the vessel will proceed to Fremantle in Western Australia. All the principal ports of that Continent will be called at, then the New Zealand ports, and Fiji, and so to Yokohama. Thence the exhibition will return home, *via* Hong Kong, Singapore and the Suez Canal, all the Far Eastern and Indian ports of any importance being visited *en route*. The whole voyage will last 542 days, of which 346 will be spent in displaying the exhibition at the 35 places to be visited.

The route has been chosen, not only to include the great markets for manufactured goods, but so that each country shall be visited at a time when the climatic conditions are most favourable to business. It has been further arranged that exhibits may be changed at certain places, for obviously much merchandise suitable, say, for the South American markets, will not appeal to the buyers in South Africa, Australia or the Far East. Canada will not be visited at all on the first voyage of the ship, an omission many people will regret, but to do justice to the Dominion would involve more time than could well be afforded and would make it very difficult, if not impossible to arrange the time-table to suit other markets. Another omission is the port of Valparaiso, but as the vessel will spend a week at Monte Video and a fortnight at Buenos Ayres, it is probable that Chilean buyers will not omit to visit it.

The exhibition ship, "British Industry," which is to be laid down in the yards of Messrs. Swan, Hunter and Wigham Richardson, Limited, at Wallsend, will be 550 ft. long, with an extreme breadth of 74 ft. 9½ in. and a moulded depth of 44 ft. 6 in. to the shelter deck. She will be built after the style of a first-class liner, so far as accommodation for trade representatives, exhibition officials and others is concerned, but her special feature will be four exhibition decks, long clear spaces the full width and the full effective length of the vessel, and 10 ft. in height between decks. These will be laid out with stands, show-cases, &c., suitable for the various products to be displayed, and compressed air, electricity, running shafting, and probably steam and hydraulic power will be provided for exhibitors who may desire to give working demonstrations of their machinery. Official interpreters will be carried on the vessel, which will also be furnished with a printing press for the preparation of programmes, catalogues, trade circulars and a daily paper. The exhibitors and the visiting public will have the conveniences of an inquiry bureau, reception lounge, consulting rooms, writing rooms, library, bank, insurance office, telegraph office and telephone exchange.

The vessel itself will be in the nature of an exhibit of British shipbuilding and engineering. She will be propelled by three Diesel engines manufactured by leading British firms, and these, together with all her auxiliary machinery, will be open to inspection as part of the exhibition. The pumps, fans, heating plant, refrigerating machinery, evaporators, lifts, sanitary appliances, &c., will all be chosen with a view to providing as comprehensive a selection of British products as is compatible with sound engineering. Even the minor fittings of the vessel will serve an exhibition purpose, the cabin hardware, the cutlery, the curtains in the saloons, the chairs and lounges, and even the paint itself will all be chosen with a view to the encouragement of British trade. In this connection it should be mentioned that the word British is not restricted to the inhabitants of these islands. It is used throughout as applying to "the community of nations known as the British Empire," so that the manufactures of Canada, Australia, India, &c., will have equal opportunities with those of the mother country to make their products better known in the markets of the world.

The exhibition space is rented in units of 50 sq. ft., each unit being 8 ft. frontage by 6 ft. 3 in. deep, although of course sufficient adjacent units can be rented to make up any sized stand that may be required. The rental of a unit of space for the complete voyage varies from 1,350*l.* to 2,100*l.*, according to deck and position. Alternatively to these stands exhibitors of small articles may rent glass show-cases or counter cases at figures ranging from 525*l.* to 625*l.* Trade representatives travelling on the ship will be carried for an inclusive charge of from 1,500*l.* to 3,000*l.* for the whole trip, such tickets being transferable to any representative of the same firm. The Exhibition Company will arrange for adequate publicity concerning the ship being given in advance of its call at the various ports, and the co-operation of British Trade Commissioners and other officials should ensure a successful exhibition at every place. The scheme is a bold one, but it may have far-reaching effects in promoting British trade. How necessary something of the kind is may be gathered from an instance which was brought to our notice recently. A steam turbine plant of considerable size was required by a municipality overseas, and although the engineer sent inquiries to one or two British firms he omitted one who might with some reason consider themselves to be the most important of all. When his attention was called to the fact he explained that he had never heard of such a firm, or he would certainly have asked them to tender. We think it will be admitted that the fault lay rather with the firm than with the buyer, and doubtless there are many such cases which a tour of such an exhibition of the British Trade Ship would render impossible in future.

AGRICULTURAL TRACTOR TRIALS.

SHRAWARDINE, a small village about 6 miles from Shrewsbury, was selected this year for the annual trials of agricultural tractors, organised by the Society of Motor Manufacturers and Traders. While the facilities for access to the site are not too favourable, in other respects it is admirably adapted for the purpose in view, as it provides 23 good-sized arable fields within an area not too large to be impracticable. Nevertheless a considerable amount of exercise is called for in the inspection of the various machines at work, as the extreme length of the area is well over 2 miles, and the width over a mile and a half, while an indefinite additional amount of rapid walking is involved in following the progress of any particular machine. Altogether about 500 acres of land will have been ploughed or cultivated for the purposes of the trials, which commenced last Tuesday morning and will finish to-night. Most of the soil is in excellent condition for working, but two or three fields, including one in particular in which some old clover and rye grass is being broken up, are so hard that horse-ploughing would hardly be practicable in the present state of the land. Several tractors, however, are pulling three-furrow ploughs through it without the least difficulty at the time of writing, and the work is as good as the nature of the land will permit. The tractors, of whatever type, appear to do their duty efficiently and without trouble, but neither slipping nor sinking-in are to be feared in the present weather, so that the quality of the work chiefly depends upon the implements they are hauling.

The trials this year are not competitions in the direct sense of the word, as no prizes are to be given and no awards made. They are really demonstrations of the machines, but their technical value lies in the fact that arrangements have been made for the first time in this, or any other country, to determine the power actually required to plough or cultivate land of various kinds and to various depths, and to co-ordinate these figures with the quality of the work done. Forty tractors were entered for the trials, and only two machines failed to put in an appearance, so that the actual starters numbered 38, representing 27 different kinds, and 22 different manufacturers. Every one of these machines is being tested on a 6-hours' continuous run by means of a recording dynamometer invented by Mr. George W. Watson, M.I.Mech.E., the consulting engineer to the society, who is in charge of the technical results of the trials. Ten Watson dynamometers are in use, which record graphically, automatically and continuously the

speed of the tractor, the drawbar pull and the depth of the furrow at any instant. The scale of the diagram is 1⅝ in. long for 100 ft. of furrow, and the depth scale is one-tenth full size. The appearance of the chart is very interesting. The time taken in the turning of the plough at the headlands and the greatly decreased drawbar pull during this time are, of course, very striking, but the effect of the plough striking a big stone or going through a hard cart track or footpath are also quite noticeable, both in the depth diagram and that of drawbar pull. It is even more interesting to note how the difference in the evenness of drawbar pull between a wheeled tractor and a caterpillar machine is rendered visible, the appearance of the chart enabling the type of tractor to be stated with certainty. We shall shortly illustrate Mr. Watson's instrument together with some typical records.

At the time of writing, tests have been carried out on all types of tractor to ascertain the maximum drawbar pull when the machine started slipping badly, and the maximum working pull consistent with good work. The first tests were conducted by causing the machine to haul two or three other tractors, the brakes of which were applied until the tractor under test could only just make progress. Of course, such tests depend almost entirely upon the nature of the ground and the type of spuds fitted to the driving wheels. With sufficiently enormous spuds in reasonably soft ground, any tractor could be stalled for lack of engine power before the wheels would slip. In the tests, the ground was dry and somewhat hard, and the machines had the spuds ordinarily used for ploughing. We shall give the results later, together with the weight and other particulars of the machines concerned. We may mention, however, that only two machines were limited in their drawbar pull by lack of engine power, and neither of these was a caterpillar. One competitor, whose wheels skidded with a pull which he considered unduly low, asked that he might change the spuds with a view to securing a better grip of the ground. Permission was granted, and overhanging angle-iron spuds were fitted in place of similar ones which only extended to the edge of the wheel rims. Contrary to expectation the result was somewhat worse than before, but in softer ground the longer spuds would probably have been beneficial.

The margin of drawbar pull between that required for the best work and that which caused skidding was generally from 20 per cent. to 50 per cent., so that the skidding difficulty is not serious when the land is in a reasonable state. The caterpillars, of which there were three, naturally showed good adhesion, but although higher drawbar pulls were obtainable with some of the wheeled machines, no useful conclusion can be drawn until all factors of weight, condition of soil, &c., are taken into consideration. One somewhat interesting comparison may be noted, however. The Renault Company entered two machines, one of the wheeled type and the other a caterpillar. Each had a similar engine, with four cylinders, 3·7-in. bore by 6·5 stroke, which at a normal speed of 1,100 r.p.m. had a rated horse-power of 24·5. Each machine had three forward and one reverse speed. The caterpillar machine had a couple of 13-in. chain tracks, 5 ft. centre to centre of sprockets, and the other had a pair of driving wheels 3 ft. 10 in. diameter by 12 in. wide. The caterpillar weighed 3¼ tons, as compared with 1 ton 14 cwt. for the wheeled machine, and had on test a limiting drawbar pull of 4,840 lb. as against 2,400 lb. for the latter. This is about the most direct comparison which can be made between the two types, as both are equally powered and built by the same firm. One can draw many inferences from the facts, some of which might be justified and others not.

It is somewhat surprising to find that the two-cycle hot-bulb engine for using crude oil does not find more favour for tractor work. Only one of all the machines entered at Shrawardine is fitted with such an engine, and this is indeed the only two-cycle engine of any kind there. The engine is of Swedish design, and has only a single vertical cylinder, 6·85 in. bore by 7·32 in. stroke, rated at 13·4 h.p. when running at its normal speed of 600 r.p.m. We watched it pulling a three-furrow plough on the hard clover field, and although it got along as well as could be desired, the irregularity of turning effort, in spite of heavy flywheels, seemed to be reflected in the quality of the work it was doing on this hard land. The dynamometer records of this set will be paticularly interesting. The exhaust was rather smoky, in fact this was the only tractor we saw smoking at all, but a little smoke is not of much account in a 20-acre field. The ordinary four-cycle engine appears to be in firm possession of the tractor business, but there seems an opinion that next year, or soon after, we may have the six-cylinder engine in use on account of its greater steadiness of pull.

Next week we shall give tabulated data of the machines concerned in the trials, and such data as to their performances as are available. Meanwhile, we may repeat that the trials are being conducted in a scientific manner with a view to getting really useful facts concerning the power required and the cost of performing the principal tillage operations by the respective machines. There is every reason to believe that the report of the Shrawardine trials will be of permanent value, both to the manufacturer and to the purchaser of tractors and implements for use with them. We felt ourselves compelled to criticise the futile nature of the report of the judges on last year's Lincoln trials of tractors, and our opinion as to its ineffectiveness is more than confirmed by the comments one hears expressed upon it at Shrawardine by farmers, competitors and officials alike.

SHIPPING PATENT EXTENSION.

A CASE was recently decided in the High Court and reported in R.P.C., vol. xxxviii., page 267, which dealt with some very important points to investors who have owned patents now expired without any attempt having been made to prolong them. The patent in question related to a method of constructing vessels comprising approximately vertical sides with one or more recesses or grooves at or near the water line longitudinally of the ship. This was said to have great advantages by imparting greater strength, less dead weight and to produce a steadier ship, but it was suggested that the invention has not been used to a great extent owing to the disinclination on the part of shipbuilders to adopt such a novel construction. The patent was assigned to a company, the inventor receiving a number of shares therein. The patent being dated as of 1905, any petition for extension under the current Act of 1907 should have been presented in 1918. It appears that the company at that time considered the question of extension, and they received more or less conflicting advice as to whether an application for extension would be likely to succeed. It seems that ultimately it was decided not to apply for prolongation, and this fact of the owners having the material before them and very carefully considering it, then determining to take no action, was a point that they had some difficulty in overcoming at the trial. In fact, the Judge said that if the matter rested on the old legislation alone plus the power of the Court to extend the time of the presentation of the petition at its discretion, he would refuse the application.

In addition to the above facts, however, the Patents and Designs Act of 1919 had to be considered. In 1920, over a year after the patent had expired, it was sought to lodge a petition for extension under the new Act, and this was granted without prejudice to the objection that it was out of time. This new Act provides among other things, that where by reason of hostilities the patentee as such has suffered loss or damage, application for extension can be made in a particular way and in that event the Court in considering its decision may have regard solely to the loss or damage so suffered by the patentee. It will be noticed that there is no time limitation in this particular part of the section and on the amended Act as a whole it appears the petitioners felt they had a reasonable case. They showed that nine ships had been built up to 1914, one in 1917, one in 1918, and one in 1921, and they further alleged that Government restrictions as to shipbuilding during the war had prevented the full application of the invention.

Between the time when the company originally decided not to apply for prolongation and the date of presenting this petition it had been arranged that a definite interest was acquired in the patent by the original inventor, a point that is of importance in all cases where prolongation is sought, That was a fact in favour of the application.

It was also proved that considerable advantages were obtained according to the invention and that, as already mentioned, the war prevented any great use of the improvements. In fact, owing to the war, shipping construction was stopped, except in accordance with standard practice, and it was impossible to use the invention at all.

In view of the evidence, the learned Judge held that there was no doubt whatever that the result of the war was to cause loss and damage to the patentee as such by diminishing the number of vessels on which he or the company to whom he has assigned the patent would have had an opportunity of licensing the makers to use the invention. He, therefore, found that there was cut out of the useful life of the patent substantially four and a-half years, and he granted a prolongation for an equivalent period. In doing this he imposed certain conditions for the protection of any infringement of the patent which may have taken place after the date on which it was declared void, adding that the persons who ought not to be precluded from the invention should be persons in cases where there has been either an order given for the construction of a vessel or where shipbuilders have actually commenced construction.

NOTE.

JUBILEE OF THE MONT CENIS TUNNEL.

On Saturday last the jubilee of the Mont Cenis Tunnel was celebrated, the inauguration of this great achievement having taken place on September 17, 1871. The Mont Cenis tunnel had the distinction of being the first of the great tunnels through the Alps. It was authorised in 1857, and work was commenced on it almost immediately, and the mountain chain was actually pierced at the end of 1870. Several months' further work was required before the tunnel was enlarged and completed sufficiently to make possible the passage of trains. The work was carried out under the famous engineers Sommeiller and Grattoni, the first of whom, whose life is commemorated by a statue at his native town of Annecy in Savoy, unfortunately died two months before the great task was completed. Although tunnelling arouses comparatively little interest now, unless conducted under extraordinary conditions, it must be remembered that, at the time of this work, such an undertaking involved a considerable degree of enterprise and many of the conditions to be met with were entirely novel. The tunnel is just over 8 miles in length, and the highest point (4,237 ft.) is 5,320 ft. below the crest of the range above. The work of piercing the range was comparatively slow until compressed air rock drilling was introduced, this being the first time in which this system was successfully used for so important a work. Although used for the heading only the introduction revolutionised tunnelling methods and greatly expedited the completion, though other and simpler rock drilling machines than those adopted by M. Sommeiller had been brought out some time previously. The power was supplied by water-wheel driving air compressors. An account of the Sommeiller machine, and a full description of the Mont Cenis works, were given in ENGINEERING, vol. vi, in 1868. The successful ending of the Mont Cenis enterprise at once gave encouragement to other schemes, and the St. Gothard tunnel was begun in 1872 and completed in 1880, to be followed by others.

OIL PROSPECTING IN AUSTRALIA.—Petroleum shale has for many years been worked in Australia, and it is known that the strata in which petroleum is found exist in large quantities. Prospecting for oil is being vigorously conducted throughout the Commonwealth in consequence of the 50,000*l.* reward for payable deposits offered by the Federal Government. The quantity of oil to be recovered before the Federal Government's reward can be claimed is stated to be 50,000 gallons. A State Act of Western Australia, in addition, provides for the issue of licences to prospectors for oil with liberal rewards for discoveries in payable quantities.

THE INSTITUTE OF METALS.

The autumn meeting of the Institute of Metals took place in Birmingham last Wednesday and Thursday, and is being continued to-day. This is the second time that the Institute has met in Birmingham, the first general meeting having been held there in the autumn of 1908, as we recorded at the time (see ENGINEERING, vol. lxxxvi, pages 658, 695 and 830), under the chairmanship of the late Sir William H. White, the first president. On Wednesday last, the members assembled at 10 a.m. in the Examination Hall, Municipal Technical School, Suffolk-street, when the Lord Mayor of Birmingham, Alderman William A. Cadbury, opened the meeting with an address of welcome. The Lord Mayor said he was glad to take a part in the proceedings of the Institute by presiding at the opening ceremony, and to extend to all members the cordial greetings of the City on the occasion of this, their second visit. The Institute linked up a number of important trades, called "the Birmingham Trades." He then referred to the souvenir booklet on Birmingham which had been presented to the members by the local reception committee; this booklet gave a history of the development of the Birmingham industries, starting from a very early period, and the Lord Mayor alluded to the great strides which had been made both in actual manufacture and also from the point of view of the health of the workers, not only since the commencement of the industrial period, but also since the date —1908—of the first meeting of the Institute. It was fitting, therefore, that the Institute should gather together again in Birmingham; the City was proud to receive them, and he hoped their work on that present occasion would have the effect of making possible further national progress.

In the course of his reply, Vice-Admiral Sir George Goodwin, the chairman of the Institute, stated that on visiting Birmingham, the Institute felt they were coming home again. He (the speaker) was pleased to be able to add that since their last meeting in Birmingham—the meeting which, practically, marked their birth—the membership had increased from 200 to 1,400. Birmingham was the centre of non-ferrous work of every class. A large proportion of this was scientific work carried out at the University and technical schools, and a large proportion also represented practical work in the numerous establishments distributed over the City and its immediate surroundings. The nation felt greatly indebted to Birmingham for both. In the name of the Institute, he thanked the Lord Mayor and, through him, the City for their cordial welcome and their kind reception.

The chairman then announced that the next President of the Institute would be Mr. Leonard Sumner, O.B.E., M.Sc.

He then read a letter from the Institution of Mechanical Engineers, inviting the members of the Institute to be present at the Institution's meetings to be held on October 21 and 28, when a Report by Dr. Rosenhain, S. L. Archbutt and Dr. D. Hansen, is to be read and discussed. The subject to be dealt with is on the Alloys of Aluminium.

The chairman next stated that the Hon. Local Secretary of the Birmingham meeting, Mr. G. W Mullins, had suggested to the Council that at each provincial autumn meeting a lecture be delivered on some subject connected with the work of the town and district visited, a lecture which would appeal not only to scientists, but also to workers, and the term "workers" to be understood in its broadest sense. The Council had welcomed the suggestion, and this suggestion will be followed in the future; the Council thanked Mr. Mullins for having put it forward.

The Properties of Some Nickel-Copper-Aluminium Alloys.

The first paper dealt with at the meeting on Wednesday morning, the 21st inst., was the one having the above title, by Professor A. A. Read and Mr. R. H. Greaves. It was read in abstract by the latter. We reproduce it, in abstract also, on page 453 of this issue.

The discussion was opened by Dr. Rosenhain, who found the paper a welcome contribution to the researches on these series of alloys. The authors had found that their hardest product was obtained by re-heating the quenched alloy for some time at 600 deg. to 700 deg. It would be found that a number of alloys hardened by quenching and tempering.

Miss Gayler asked for further information as to how the measurements were taken, and whether they were taken immediately after quenching. There was no reference made to the time of annealing, and this was an important point. The authors had referred to a number of exploratory alloys made in small quantities, hot forged and heat treated. Miss Gayler asked whether low-temperature annealings were made on these. It struck her that the annealing temperature of the authors throughout was too high.

Dr. Hatfield challenged the authors' statement to the effect that in the quenched alloys the fatigue limit was about 2 tons per square inch above the load giving a permanent extension of $\frac{1}{2}$ per cent. in the tensile test, and that a considerable extension occurred in tension at stresses far below the fatigue limit. He would like the authors to be more explicit as to the basis on which that conclusion was drawn.

Dr. Bengough was specially interested in the authors' micrograph, Fig. 15, of an alloy comparatively low in nickel and aluminium, showing lines through the illustration and through neighbouring crystals. The lines could hardly be due to rolling and he would like the authors to explain the occurrence of the lines.

Admiral Goodwin asked for more information on the coefficient of expansion of the alloys; an alloy might be deemed satisfactory in the first instance, and this same alloy might lead to trouble in practice through not knowing its coefficient of expansion.

In the course of his brief reply, Mr. Greaves said the authors made no tests below an annealing temperature of 300 deg. and the maximum time at that temperature was three or four days. In reply to Dr. Hatfield, the evidence for the conclusion challenged was given in the paper, the statement also being made that a similar behaviour had been observed in other material. With reference to Dr. Bengough's remarks on Fig. 15, he believed the streaks were due to the remains of the dendritic structure of the original cast material. The other photographs, taken with a higher magnification, also gave indications of that streakiness.

The Effect of Increasing Proportions of Lead upon the Properties of Gun Metal.

The second paper taken at the meeting on Wednesday morning was by Mr. R. T. Rolfe, dealing with the effect of the increasing proportion of lead upon the properties of gun-metal. It was read by the author, and we shall reproduce it in abstract in a future issue.

Dr. F. Johnson, who opened the discussion, said that foundrymen would be grateful to the author for the useful work he had carried out. The author had stated that all the lead alloys contained nearly 0·5 per cent. of arsenic. As this, however, appeared to lead to no particular falling away in the quality of the nominally lead-free metal, it was not considered that the presence of the arsenic could have any masking effect on the true action of the lead. A real change appeared to have come over the author's attitude towards arsenic. Formerly this could only be permissible up to 0·3 per cent.; now he found that 0·5 per cent. appeared to lead to no particular falling away in the quality of the metal. Shakespeare said that the devil could quote Scripture for his purpose; if arsenic is the devil it was once thought to be, the author appeared to have given him a good hearing. In regard to proving, he (the speaker) asked whether the temperature of the chill mould was taken: a variation of this would affect the properties of the cast bar. He also asked whether any attempt was made to gauge the fall of temperature during pouring. With reference to the source of the material for analysis, was any segregation of lead looked for? Comparing the author's former contribution with the present one, he (the speaker) found that arsenical gun metal of practically the same composition and pouring temperature had different mechanical properties from the present ones. (The speaker here quoted the differences found based on the influence of lead.) The author had also said that at a point corresponding to the presence of about 1·5 per cent. of lead, the strength and ductility began to fall away and the hardness increased. This increase of hardness, the speaker said, would appear to be due to an increase in the relative proportion of eutectoid, owing to the Cu/Sn ratio increasing with replacement of copper by lead.

Mr. J. S. G. Primrose said the conflicting opinions quoted by the author, when dealing with the papers of other experimentalists, might not be found to show such wide discrepancies if the several conditions of casting and use of the gunmetal were more fully explained. The author assumed that the presence of 0·5 per cent. of arsenic would not mask the effect of the lead additions; it would be preferable to make sure of this. These two elements together might possibly have an effect that either alone would not have. Athough the author had used a pit fire and natural draught, it was rather long to take 2½ hours in which to melt a charge in a 50-lb. pot. More especially when no flux or covering was used, which was not usually considered good melting practice. For 120-lb. or 200-lb. charges much less time would be ample, with less liability for gas absorptions to occur. He (the speaker) asked how the lead additions were made, as, if added alone and not as a 15 per cent. alloy with copper, or too soon, there would be a strong tendency for the cast to be richer in lead at the end of the pouring than at the beginning, even with stirring. Any improvement which may occasionally appear in the results of testing "leaded" gunmetal was always considered by him (the speaker) as the purely mechanical one of filling in the gas cavity caused by defective melting of the metal either by overheating or a too-prolonged stewing in the furnace. This increased strength was only observable in poor gunmetals and was most probably caused by the liquation of the lead into the gas holes, closing them up sufficiently to permit of greater ductility than an empty spot would give. The view-point of strength and ductility of specially-cast test bars given by the author were hardly a sufficient criterion to induce an Admiralty inspector to permit more than 0·5 per cent. of lead in his castings, some of which were of a considerable size. In spite of the repeated impact figures being greatest with 0·86 per cent. of lead in the sand-cast bars, it was highly significant to him (the speaker) that the highest value was obtained in the chilled cast bars made with the alloy most free from lead. The author had said that practically all the lead separated out when the metal was solid; it would be difficult to imagine (the speaker added) any of it remaining in solution at all, unless with no zinc present and higher percentages of tin and lead, when these might form an eutectic. The instance of lead segregation mentioned by the author showed the difficulty of finding by analysis all the quantity of lead intentionally added to gunmetal or other highly-cupriferous metal.

Admiral Goodwin, referring to the author's statement to the effect that from the view point of strength and ductility there appeared, in the case of sand castings, no justification for limiting in Admiralty specifications the lead content to 0·5 per cent., said this required comment; there was justification for this limit which had been arrived at on the advice of members of the Institute. There was a tendency in marine practice to have recourse more and more to superheat, and the advice given was that the percentage just named should not be exceeded.

In the course of his reply, Mr. Rolfe said there was no unsoundness in his alloys, only variations in the properties. The variations in the lead content were those in the final product. The lead was distributed as evenly as possible by stirring before casting. The gun metal was usually sand cast and not chill cast. He had found that it was not so necessary to eliminate the lead as one might think. In regard to superheat, gun metal was hardly suited for that whether it was due to the lead, the arsenic or any other constituent.

THE CASTING OF BRASS INGOTS.

A note having the above title, by Mr. R. Gendres, being a communication from the Research Department, Woolwich, was next taken. It was read in abstract by the author. We reproduce it on page 452.

The discussion was opened by Dr. Rosenhain, who congratulated the author for the step he had taken. He (the speaker) had long ago suggested that there was too much separation between the iron and steel and the non-ferrous metal researches. His experience that the troubles in non-ferrous metallurgy could be traced back generally to the original ingot, and the author had strongly emphasized the point. If the ingot were not a perfect one, one could not get a perfect product out of it, particularly if the work done upon it were at all severe. The rate of pouring required to be given attention to. It was possible to avoid cavities by regulating the "keenness" of the stream from the crucibles, and in regulating both the metal flow in the mould and the path which the metal followed in the mould. The time taken in pouring also came in; if the metal were poured not much faster than it solidified the cavities were got rid of. This could not be done if the mould were long and narrow.

Mr. T. G. Bamford emphasized the harmful effect of blowholes and iron metallic inclusions in the casting, and these persisted through the successive operations. These would be eliminated by following the practice which obtained in pouring steel into ingot moulds; but there were some drawbacks to this in a brass foundry and the innovation would not be looked forward to by the brass caster. He (the speaker) advocated a high pouring temperature; this was important in the case of 70 : 30 brass.

Mr. H. Moore said he had been in very close touch with the work done by the author; the experiments had been carried over a long time and he was able to confirm the results, also the fact that a long narrow ingot was not sound.

Mr. R. J. Redding had found that what foreign material there might be in 70 : 30 brass had come from the mould. If this were graphite coated, the graphite might scale off and be taken up by the metal. He supported Mr. Bamford in his advocacy of a high pouring temperature; the caster had to be trained to cast always at the right temperature and correct speed. Ladle pouring in a brass foundry would be a difficult matter, unless the size of the ingot moulds and of the charge justified this.

In the course of his reply, he said he had seen a ladle used for bottom pouring, the weight of the charge being low and the temperature 1,200 deg., when excellent results were obtained. He did not condemn long narrow ingots for all purposes; a governing feature in this respect was whether the mechanical properties of the piece to be made from them were of importance in actual service.

THE DENSITY OF COPPER-ZINC ALLOYS.

The fourth paper taken on Wednesday was by Mr. T. G. Bamford; it dealt with the density of copper-zinc alloys. It was read in abstract by the author. We shall reproduce it, in abstract also, in a future issue.

The author pointed out that the density of alloys was important both from a theoretical and a practical standpoint, since when the correct density was known it was possible to determine whether casting conditions had been satisfactory. Experiments conducted with alloys made from pure metals in sand and in chill moulds, showed that there was a contraction in volume, *i.e.*, an increase in density due to alloying with mixtures containing over 25 per cent. of copper, and that the density of the sand cast (or slowly cooled) alloys was generally less than that of the chill castings, but at the points where the liquidus and solidus coincided on the constitutional diagram, chill and sand castings gave the same values.

Professor Turner, after a statement to the above effect, said it was not safe to imply that a metal was sound because when it was cut with the saw it showed a smooth surface; holes in the metal might have been filled up by the action of the saw. Hitherto there had been no accurate data as to density. The author had pointed out a number of varying results, showing that the rate of cooling and the amount of work done on the metal altered the density. He had stated how a maximum density could be expected, and if a lower density was arrived at in actual practice, the metal had holes in it.

Dr. Rosenhain said if it were possible to determine the density of castings, the author's curves would prove extremely useful. He (the speaker) referred to the work carried out by Bragg and Hill, and others on the distribution of atoms in the crystals of metals, the work giving a new illustration of solid solutions and intermetallic compounds. It was necessary to secure that alloys were in physico-chemical equilibrium before density measurements were made, and great care and skill were required for these measurements, for they had to be made with very great accuracy. Then data of value and liable to be used for the internal study of metals would be at hand.

Dr. F. Johnson, referring to the curves and the different densities for sand and chill castings, asked whether green sand or dry sand was used; it was advisable to use dry sand.

Mr. Bamford, in his reply, said he agreed with Dr. Rosenhain's remarks. Sand castings were porous, and the sand he used was well dried; it cohered satisfactorily and there was no complication with the pattern. It was difficult to do the work in absolutely dry sand.

EXPERIMENTS IN THE WORKING AND ANNEALING OF COPPER.

The fifth paper was by Dr. F. Johnson, relating to experiments in the working and annealing of copper. It was read in abstract by the author. We propose to deal with it in a forthcoming issue.

It was divided into three sections. Section I gave evidence in favour of the probability that the "critical ranges of deformation" result from stages of abnormal plasticity during rolling; it was suggested that during these stages the metal actually lost some of the increase of hardness conferred in earlier passes. The volume-changes which take place showed a decrease of volume up to 85 per cent. reduction. There was a maximum specific gravity at this point. Section II described annealing experiments on copper strips, whilst Section III dealt with the low-temperature annealing of cold-drawn copper rods of varying compositions. The substitution of iron for oxygen in arsenical copper retarded the rate of softening, the softening range of temperature being widened.

Professor Turner found the author's line of study useful and important, and welcomed the information he gave.

THE EFFECT OF PROGRESSIVE COLD-DRAWING UPON SOME OF THE PHYSICAL PROPERTIES OF LOW-TIN BRONZE.

The last paper taken at the meeting of Wednesday, the 21st inst., was the one having the above title, contributed by Mr. W. E. Alkins and Mr. W. Cartwright. It was read in abstract by the latter.

It gave the results of an experimental inquiry into the effect of progressive cold-drawing upon the tensile strength, specific volume and scleroscope hardness of a bronze with rather less than 1 per cent. of tin. The results showed that the variation in physical properties with reduction was very different at different stages in the reduction. The most rapid and important changes in properties occurred after a reduction of 85 per cent. of the original area; it was precisely over the range where practical difficulties are met with during drawing that the most pronounced variation in properties was found.

Dr. F. Johnson appreciated one point made by the authors, namely, their statement to the effect that the specific volume reduction curves for their three series conformed to the same general type. There was a similarity between the authors' and his (the speaker's) curves. The materials were, however, different; the authors' was cold-rolled whilst his (the speaker's) was annealed. He asked the authors to explain their hardness figures.

Dr. Desch found that the present paper with the former one by Mr. Alkins, supplied useful information upon a difficult question. The specific volume reduction curves were determined very carefully and the curves ran very smoothly, showing slow and gradual increase in specific volume. The great increase at the curve end was, no doubt, due to overdrawing, which meant that the increase in specific volume shown there was an apparent one only. He asked whether the authors had experimented as to the time effect in that particular test. The minimum in the curve for two series was very suggestive of an unstable state.

Dr. Rosenhain was interested to find the authors continuing the work on cold drawing. He asked whether the alloys were really in a state of equilibrium. The specific volume changes struck him as the most interesting feature of the results. It was remarkable that at a certain stage of the cold work the density increased, a phenomenon which it was difficult to explain. The increase in density at a certain stage was not so marked with pure copper as with an alloy. It would be interesting to know whether silver or gold showed a similar behaviour.

Dr. F. C. Thompson appreciated the care with which the authors had carried out their work. They had taken all reasonable precautions and their results were of value. Dr. Desch had suggested that overdrawing beyond a certain point was responsible for some specific volume results shown; he (the speaker) felt that something else came in for the curves fell extremely well. If overdrawing had been the cause, he thought a more irregular curve would have been obtained. Dr. Rosenhain had suggested that the material was not in a state of equilibrium to start with; to this he (the speaker) would remark that every material showed some sort of critical change. Mr. Longmuir had a very similar arrest. The critical point shifted its position with the material, but it was an inherent part of the curve. A probable explanation was that in cold drawing something in the nature of curves of maximum stress were produced and at some point the curves met at different sides; there a critical change took place.

When the above papers had been read and discussed, members proceeded to the Grosvenor Rooms, Grand Hotel, Colmore-row, where they were entertained at luncheon by kind invitation of the Metal Trades' Association. In the afternoon visits were paid to the chemistry and physics, mining and metallurgy, and engineering departments of the University, Edgbaston, and in the evening a civic reception by the Lord Mayor was held in the City Art Gallery.

On Thursday, the members gathered again in the Examination Hall of the Municipal Technical School, at 10 a.m., when a further set of papers were read and discussed. In the afternoon, a number of groups were formed to visit 15 different works in Birmingham and district. A garden party was held in the evening, arranged by the local Reception Committee. To-day, a motor excursion takes place at Kenilworth, Warwick and Stratford. We shall deal further with the proceedings in our next issue.

(To be continued.)

LITERATURE.

The Frontier of Control: A Study in British Workshop Politics. By CARTER L. GOODRICH. London: G. Bell and Sons, Ltd. [Price 7*s.* 6*d.* net.]

WHILE the control of industry by the workers is no new thing, and exists more or less all over the world, it has come very much into prominence in recent years, and has taken quite new forms. Control has always existed not only in industry but even in military affairs. Many generals have been hampered in their movements by the refusal of the rank and file to follow them; in fact, Alexander the Great was actually prevented from carrying out all his plans. In industry passive resistance frequently limits the methods of production, and there are many parts of the world at the present time where modern methods cannot be used because the population prefers going on in the old way even though they could get higher wages by changing.

In England, however, control at the present time has mainly taken the form of agreements between the trade unions and the employers. No doubt

there are many instances where, by simple passive resistance, the workers prevent certain methods of production, but the main points are agreements with the trade unions. Under these circumstances the book under review, setting out the ideas of the workers, or at all events the trades union leaders who represent them, is useful as giving the position up to date. The author states the desire for control, and then goes on to state the various forms it has taken. Wages and hours, of course, form the first subject for control, but in addition to this a great many other points are mentioned. Employment, unemployment and the measures to meet it, the right of a firm to sack men at will, promotion, the choice of foremen, trade policy and a good many other points are all matters in which the trade unions have claimed control and, at all events, in some cases obtained a certain amount.

The difficulty, as is mentioned by the author, is to tell to what extent control apart from the pure questions of wages, working hours and conditions of labour is really desired by the mass of the workers, and to what extent this demand is simply made by their leaders. After all, trades union leaders are only human, and it is a very common thing for people to feel that they are more capable of controlling affairs than those in charge. In fact, it is a very ordinary thing for success to be attributed to other qualities than brains and hard work. "I took the chances they wouldn't and now they are calling it luck," might be said by many successful men. Money is, however, essentially made not by doing what one likes but what other people like. An employer finds this just as much as anyone else. A keen mechanic, for instance, loves designing fresh machines, but the most profitable business is manufacturing a standard article for years without change. Further goods have to be made to the customers' taste, not to a manufacturer's desires.

Granted that the choice lay between control and higher wages would the mass of the men prefer the former? It appears to be impossible to tell, but in one leading question the mass of the men do not appear to have been of the same opinion as the trades union leaders quoted by the author. These leaders stated that quite apart from questions of wages and hours the workmen objected to working for private profit, and that their wish was to work for the State. Now we have in the last few years had a chance of seeing to what extent this is really the wish of the working man. There is certainly no evident desire of men to work in the dockyards, arsenals, &c., harder and for less money then men do for private employers. Another point for consideration is the fact that many, if not most, of the instances of control quoted are taken from the period of the war or the first eighteen months after it, and these were very exceptional years. It remains to be seen how far the trades unions will insist on control in a time when work is scarce, and if employers will only employ men in their own way. This question is not dealt with by the author, who has simply stated the facts of the case. To those who desire to know how far trades union control has gone the book will be of great interest. It may be specially useful to those who wish to know how far they will be allowed to control their own works before they invest money in any form of factory in this country.

Hydraulic Forging and the Plastic Deformation of Steel and its Heat Treatment. By Clifford O. Bower, A.M.Inst.C.E., A.M.I.Mech.E. London: The Library Press, Limited. [Price 30*s.* net.]

It is very surprising how little scientific study has been given to the principles underlying the forging of metals. The fact that metals flow under stress and can alter their shape without rupture has been known since ever metals were known, and we suppose that advantage of this property has been taken by man ever since the days of Tubal Cain. But our knowledge of the subject has remained essentially primitive.

On the scientific side the flow was studied by Tresca between 1864 and 1870 in a series of researches which have never been superseded and which still stand to-day in unquestioned pre-eminence, while other aspects of the same subject have been studied by Spring in Belgium and by Tamman in Germany, and the most recent work has been carried out by Bridgeman in America. On the technical side, however, there is almost an entire absence of published information, and a rational theory of the flow of steel during rolling or forging still remains to be discovered. A beginning has certainly been made within the last three or four years, and results have been published of work carried out at Le Creusot on a forging press, while to study the operations of rolling an elaborate mill has been built at the Bureau of Standards in Washington and research work on this mill is in active progress. But at the present day forge practice is primitive, and it will be surprising if it is not also inefficient.

In the book now before us there is much information on the subject of forging, but the author has confined the scope of his work within so narrow a degree that he has limited very seriously the scope of its usefulness. Originally published as "Practical Shell Forging" just at the close of the war, he has evidently found that the post-war interest in shells did not come up to expectations, and so to widen the interest and presumably to stimulate the sales, it has been reissued under its present title without mention of any alteration in the text or contents. Managers of commercial forging plants will look through this book in vain for any reference to the classes of work on which they are likely to be engaged—the forging of shafts, connecting rods, turbine discs or the numerous articles required in times of peace are never mentioned. It remains in spite of the change of title a monograph on shell forging.

It would be wrong of course to deny on this account that it is without interest. The author has studied the subject of shell forging with an inquiring eye and has set out a well-reasoned account of the practice in one of the best shell factories in operation during the war, and has correlated this practice with theoretical explanations which seem to fit the facts, and the result is a well-balanced volume within the limits which the author has set himself.

The operations of punching and drawing billets are discussed in great detail, and not a little skill is shown in producing an approximate theory which is sufficiently near the truth to act as a practical guide in determining the pressures required for billets of varying size and the angles of the drawing dies. A chapter explains the objects and advantages of heat treatment, and includes results on the strength of billets and forgings as affected by temperature and microstructure which have been taken from actual works records, and of course they apply in equal degree to all forgings of similar composition. The micrographs are a good feature of this chapter, and they are excellently reproduced.

The remaining chapters on presses and furnaces do not present any unusual features—they are mainly descriptions and illustrations of plant already well known, and though they render the book more complete they do not in themselves increase its value.

As a practical treatise on shell forging this book therefore possesses a definite claim to recognition for the value of its observations and descriptions of the processes employed and as a record of the highly specialised development brought about by the stress of war, but as a treatise on hydraulic forging in general it is sadly inadequate.

BOOKS RECEIVED.

The Economic-Geographical Foundations of the Upper Silesian Question. By Professor Dr. Wilhelm Volz. Berlin: Georg Stilke.

Annual Report of the Minister of Mines for the Year ending December 31, 1920. Being an Account of Mining Operations for Gold, Coal, etc., in the Province of British Columbia. Victoria, B.C.: William H. Cullin.

Department of Scientific and Industrial Research. Report of the Fuel Research Board for the Years 1920, 1921. First Section. Steaming in Vertical Gas Retorts. London: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

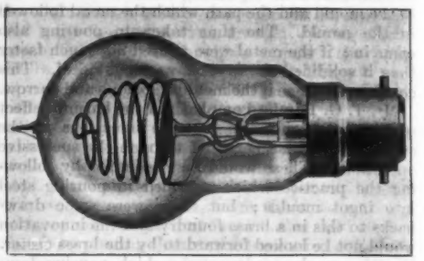
Where's Where. The A.B.C. Motor, Marine and Aircraft Guide, 1921. Compiled by W. C. Bensey and A. Dorey. London: The Red Book Publishing Company, Limited, and Technical Publishing Company, Limited. [Price 7*s.* 6*d.* net.]

Grinding Machines and Their Use. The Main Principles, Equipment and Methods of Precision Grinding based on long experience in the Design, Construction, and Application of Grinding Machines. By Thos. R. Shaw, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. Price 2*s.* 6*d.* net.

A LOW CANDLE-POWER ELECTRIC LAMP.

Although light is normally required in reasonable large units, there are various applications in which a very small candle-power unit is convenient or necessary. Examples are furnished by the case of night-lights and many other instances in which an illuminated indicator is required. The electric light has always been handicapped in this matter of small units, and for use as a nightlight, for instance, has compared unfavourably with gas or oil lighting. There has, of course, for very many years been no difficulty in making small candle-power incandescent lamps to work on low voltage circuits, but the production of a similar lamp to operate on an ordinary supply circuit has not been possible.

A solution of the very low candle-power electric lamp problem would appear to be afforded by the new "Osglim" lamp which has been brought out by the General Electric Company, Limited, of Magnet House, Kingsway, W.C.2. The patents covering the manufacture of this lamp are, we understand, held jointly by the General Electric Company and the



British Thomson-Houston Company. The general appearance of the Osglim lamp will be seen from the figure above. In dimensions and outward appearance it corresponds to an ordinary incandescent lamp and is fitted with a standard bayonet clip cap. It may be used on any ordinary circuit of suitable voltage, and no special wiring or other arrangements are necessary. The lamp is of the electric discharge, or ionic bombardment, type. The bulb contains a small quantity of neon gas, and there are two metal electrodes placed a short distance from each other and between which the discharge takes place. The outer metal electrode or cathode is of wire wound in a beehive shape, and when the lamp is energised a luminous haze appears round this cathode and provides the source of light. The light is somewhat orange of a pleasing colour, and being rich in red and yellow rays is well visible at a distance.

In addition to the illuminating lamp with beehive cathode which we illustrate, forms are made in which the cathode takes the shape of the various letters of the alphabet. An assemblage of such lamps makes an attractive illuminated direction indicator or sign. The lamp is at present obtainable in two standard ratings from 200 volts to 220 volts, and from 221 volts to 250 volts. The energy consumption is 5 watts.

WAGES, PRICES AND PRODUCTION.

To the Editor of Engineering.

Sir,—With reference to your article on page 225 of your issue of August 5 last, regarding wages, prices and production, this is one of the most interesting articles on this subject which has recently appeared in your columns, and is much more valuable than many of the general statements regarding the subject which are constantly appearing in the technical press.

One would like to have the remarks of some of the engineers who have control of motor car manufacture in this country regarding the prices that the Americans are able to sell these cars at. At the same time, it must be thoroughly understood that the question of cost of production is largely settled by the sales department. Providing the sales organisation can dispose of the material, there is no difficulty whatever in getting costs down to a very low point. This point is seldom realised, and requires to be explained.

The Americans have had this advantage in motor car production. Owing to the low price of petrol in the United States of America, there has been such a demand for cars that one out of every three families possesses a car, providing at once a good market and a constant demand for spares. How is it that in this country petrol is four times the price it is obtainable at in the United States of America?

There is no doubt whatever that production costs in this country could be brought down to as low a figure as in any other part of the world, providing works can get the opportunity of making the articles in sufficient quantities, and engineering journals, as well as engineers, should stop the use of such a general phrase as "what we want is increased production," inferring as they generally do that labour in our shops is not so efficient as it is in other countries. It is a well-known fact that

British mechanics are sought for all over the world, and the fact that the Ford Company has installed works in this country, and are selling tractors from their factory in Cork at a low figure, is sufficient proof that low production costs are possible even when wages are higher than the standard rate we are paying at the present time.

What would be interesting, if it could be obtained by such a journal as your own, would be definite figures, what the production of an engineering works should be *per employee per annum*, say, for a works manufacturing *motor cars, electrical motors* and *steam engines*. It would then be possible for any firm producing any of these articles to say definitely whether they were working at 50 per cent. or 100 per cent. efficiency. To state merely that "our production is not what it ought to be" conveys no meaning whatever. During a period of ten years I have tried to collect figures on such a basis as this, but it is surprising to find how few firms have any knowledge of such facts as this or what their production per head ought to be.

Cost of production and increased production are wrapped up so closely with sales organisation, design and jigs and tools that the question of whether labour is as efficient as it ought to be is a comparatively small factor. Personally, I have had control of men now for twenty years, and have never had the slightest trouble in being able to get men to follow a lead for increased production, when it was shown to them that the management was prepared to do everything possible to reduce designs to the simplest form, and introduce the best methods and the best machinery for carrying out the work. I have found works where the production of the men has been low, but this has been a reflection on the management, and the men were not entirely to blame. In many cases the men have hardly been able to help themselves, and slack methods were almost forced upon them.

Neither piecework nor premium bonus systems are necessary to get low costs. With keen management and close supervision, cost of production can be kept low, and there is just as much likelihood of high costs in a shop where piecework exists as where wages are paid on the hourly rate. The Ford Company is a clear example of this, where wages are high, management keen and cost low. Many of the shops where premium bonus and piecework systems have been introduced hoping to effect low production costs, failed because piecework can never hope to cover loose methods in shop organisation.

What is wanted if we are to lower production costs is a closer study of :—

(1) Detailed production costs.

(2) A basis of efficiency on the lines of production per head per annum.

(3) On-cost showing the effect of :—

(a) Rates and taxes.

(b) Capital charges and so forth.

(4) An efficient sales organisation that will keep the works employed to its fullest extent in large quantities on standard articles.

Works managers will then be able to show as low cost of production in this country as in the United States or Germany.

Yours faithfully,

ARTHUR S. MURDOCH, Works Manager.

"Smithfield," Alloa, Scotland, September 12, 1921.

"WHITE LEAD IN PAINTING."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of August 26 you published an article on white lead in painting, including a lengthy extract from the statements made by the "White Lead Corroders" Section of the London Chamber of Commerce, printed in a pamphlet entitled "The Case against Prohibition."

May I be permitted to offer a few observations on the subject? In the first place, white lead, as you are so well aware, is used to a very limited extent on metal work. Iron oxide, graphite or an admixture of pigments is almost invariably preferred. The whole subject is a very complicated one, as those who have read "The Corrosion and Preservation of Iron and Steel," by Cushman and Gardiner, published by The McGraw-Hill Book Company, will be ready to acknowledge. The bibliography, or references to books and magazine articles on the subject, takes over 60 pages.

Engineers are very often called upon to arrange for the painting of wood, cement and other structures. The subject is, therefore, of considerable interest to them from the point of view of cost and durability. Leadless paints include the whole series of earth colours such as ochres, siennas, Vandyke brown, umber, Venetian red, Indian red, &c., and these are all cheap and last a long time. They are, of course, frequently mixed with a white pigment such as white lead, zinc oxide or lithopone.

The two last-named pigments are those which would doubtless take the place of white lead should its use be prohibited, zinc oxide for use both on inside and outside work, and lithopone for interior work only.

There can perhaps be no better proof of the value of zinc oxide than the fact that it is the sole pigment used in white and other enamels, which have proved to be among the most durable paints in existence. In passing, it may be observed that if a house were painted from top to bottom with white or tinted enamel, including even the kitchen and scullery, it would be the most economical finish. The cost of the paint or enamel would be a trifle compared with the cost of labour. If, for example, enamel cost twice as much as white lead, it would probably last two or three times as long. A simple calculation will prove the economy of such contention.

Painters who condemn zinc oxide have probably never given it a fair trial, that is to say, they have never mixed it properly. If they use as much oil and turpentine as they would for white lead and add the usual quantity of paste or patent driers, failure is inevitable. Different pigments require different mixing; for instance, the blacks, Vandyke brown, &c., require a good deal of driers, red lead none. Zinc oxide should be mixed, for inside work, with refined pale boiled linseed oil, liquid zinc driers, and as little turpentine as possible, should be added. For outside work, 25 per cent. of the thinners should consist of a good pale mixing varnish, and if this is added to the other ingredients mentioned, there will be no question as to the durability of the paint. If used in any situation where there are sulphur fumes, such as are found in most large cities, this paint will not be affected as white lead is, but will retain its colour permanently.

It has been pointed out that much of the danger to painters of white lead poisoning arises from the process of rubbing down painted work by means of pumice-stone and sandpaper owing to the dust which is thereby created. This is undoubtedly true. Such dust is very likely to be inhaled and plumbism to follow. It has been many times claimed that if dry rubbing down of painted work is prohibited that the danger will to a great extent be removed. At first sight this argument appears to be a sound one. It is, however, one which is most misleading because if even dry rubbing down were prohibited by law the provision could not be enforced. To make such a law operative it would be necessary to have an inspector on every job of painting—an obvious impossibility. If even sufficient inspectors were appointed to visit every job, say every day, it is certain that the workmen would resort to the dry rubbing as soon as the inspector's back was turned. They would rather run the risk of poisoning than be subjected to irksome regulations.

The "wet" operation of rubbing down would consist of rubbing down old painted work with pumice stone and water—which, by-the-bye, is already done—and also moistening the sandpaper with turpentine. The use of mineral oil has been suggested for the purpose, but this is an absurdity because such an oil does not dry, and it would have to be removed before the new paint could be proceeded with. If by "mineral oil" is meant a light distillate such as naphtha or benzine the answer is that both would evaporate so quickly as to render very frequent moistening necessary. Turpentine itself is, of course, volatile, and the same objection to its use, although in a lesser degree, would apply. If one desires to ascertain the rate at which turpentine evaporates a simple experiment will satisfy him. Pour on a piece of white writing paper a single drop of pure turpentine. This will leave a mark which will disappear in a few minutes, indicating that the turpentine is probably pure. If a greasy mark is left on the paper it indicates either that the turpentine is adulterated with mineral oil or that it is not turpentine at all.

In your issue mentioned are four statements purporting to prove that leadless paints would be relatively far more costly than white lead.

(1) "Their inferior hiding power necessitates more coats and proportionately more labour." As a rule three or four coats are given on new work. If leadless paints are mixed in the manner above suggested it will be found that while the first coat of zinc does not show up as well as lead, the second coat is equal, and the third coat is superior in hiding power.

(2) "More coats mean a larger quantity of paint." One coat is never used on new work and very rarely on old work.

(3) "Its lesser durability necessitates more frequent repainting." This has been dealt with above. Zinc paints properly mixed are just as durable as those based on lead.

(4) "Repainting is more difficult on surfaces previously painted with substitutes." There is no difficulty at all when repainting with zinc. A very little rubbing will be required on old work, and this rubbing down can be done with *dry* sandpaper, without any risk of poisoning.

(5) "Nothing works so easily under the brush as white lead." This is not granted. Zinc oxide mixed properly works equally as well when once the painter has become used to it. Then there is added these words: "The only seriously considered substitutes are zinc products; as these are foreign monopolies, it is not possible to estimate the price to which they may rise if white lead were prohibited."

The above is a very misleading statement, to put it very mildly. The manufacture of zinc products is emphatically *not* a foreign monopoly. I have before me a letter from the inventor of lithopone, and he tells me that his firm in Lancashire are now making about 30,000 tons a year. This product is also made in large quantities at Charlton and elsewhere. It is the base of nearly all the washable water paints and "flat wall finishes." Zinc oxide is made in this country to the extent of about 5,000 tons a year, which is not a small production for a comparatively new home industry. No doubt a certain quantity of both materials will continue to be imported, but this will create a healthy competition and tend to keep down prices.

It has been proved beyond question that an admixture of from 25 per cent. to 35 per cent. of zinc oxide added to and ground with white lead produces a far more durable paint than one which is made of white lead alone. The lead has a strong tendency to "chalk," *i.e.*, to become in a condition resembling that of whitewash, so that it rubs off when the hand or a glove is passed over it. This condition is almost invariably found when pure white lead paint is used on the seashore. The addition of the zinc oxide successfully corrects the tendency named.

It is worthy of especial remarks that almost every one of the highest class ready-prepared paints on the market—and there are many of them made by firms of the highest reputation—contain a considerable proportion of zinc oxide in their composition, and such firms do not seek to hide the fact, but state it plainly on the package or advertising matter, for example: "The paint in this can is guaranteed to be made only of genuine white lead, genuine oxide of zinc, pure linseed oil and pure American turpentine." In the United States leaded zinc, which for practical purposes may be considered an admixture of white lead and zinc oxide, is used very largely, and with excellent results. The *danger of lead poisoning when this product is used is materially lessened.*

There are some painters who used, during the progress of the war, zinc oxide paints, and were not satisfied with the results. The explanation, without doubt, is that they were unable to obtain a first-class pigment. The manufacture having stopped, such painters were compelled to use any admixture they could get hold of, hence the results were not satisfactory. It is impossible to obtain any reliable data during the unsettled conditions which existed during the war. Not only was there great difficulty in getting materials, but in many cases the principal, the manager and the technical adviser were absent.

The assertion is frequently made that if the use of white lead is prohibited, the cost of painting in general will be increased. Such, however, is not the case, as reference to the following figures will clearly demonstrate. I take the cost of materials only, because the labour of applying them will be substantially the same, whatever material is used. To-day's prices are as follows. White lead, 45*s.* 9*d.* per cwt.; zinc oxide, 36*s.* per cwt.; lithopone, 27*s.* per cwt. These will be found substantially to correspond with prices abroad. Now, when these dry pigments are mixed with the necessary amount of oil and turpentine to produce a paint, and are of a consistency suitable for applying with a brush, 1 cwt. of white lead will cover, on old work, about 650 sq. yards. Zinc oxide, however, will cover at a modest estimate 25 per cent. additional space, or 812 sq. yards. The same quantity of lithopone will cover one-third more, or 867 sq. yards.

You will doubtless be aware that a Departmental Committee was appointed in 1911 to inquire into the whole subject of lead poisoning. This committee, with the exception of one member, was in favour of the prohibition of the use of white lead. You will also be aware that the Home Secretary has appointed another committee to "re-examine, more particularly in the light of the further information, which has become available since the inquiries of the Departmental Committees appointed in 1911, the question of the danger from the use of lead paints, to workers in the painting trades, and the comparative efficiency and cost, and the effect on the health of the workers, of paints containing lead, and leadless paints, respectively. The committee is to advise, whether any modification of the conclusions and recommendations of those committees has become necessary." The committee consists of Major the Right Hon. Sir Henry Norman, Bt., M.P. (Chairman); Mr. Gerald Belhouse, C.B.E.; Mr. O. J. Kauffman, M.D.; Mr. Thomas M. Legge, C.B.E., M.D.; Mr. Alan Munby, F.R.I.B.A.; Mr. Alexander Scott, F.R.S., D.Sc.; and Mr. H. O. Weller. The secretary is Mr. C. W. Price, of the Home Office, Whitehall, S.W. 1.

After a careful consideration of the above, I claim that: (1) The prohibition of white lead is necessary because of the deaths and illness which occur from its use. (2) Regulations as to wet rubbing down, &c., are not welcomed by either employing painters or their operatives. To enforce such regulations would be practically impossible. (3) There are several leadless paints, which can be used in place of white lead. They are equally durable, as a rule cheaper, and they will not poison the men who apply them. (4) In any event, the use of white lead should be prohibited on inside work. (5) If from 25 per cent. to 33 per cent. of zinc oxide is added to white lead, the durability of the paint is much increased on outside work, particularly when applied to buildings, situated on the seashore. The danger of lead poisoning is lessened in proportion to the quantity of zinc oxide present.

Yours truly,

ARTHUR S. JENNINGS, Editor of *The Decorator*.

326, Bank Chambers, 329, High Holborn, London, W.C., September 8, 1921.

MERCHANT VENTURERS' TECHNICAL COLLEGE.—This college, in which the Faculty of Engineering of the University of Bristol is provided and maintained, has issued its calendar for the sixty-sixth session, 1921-22. This gives a full account of the college, the courses followed, lectures, &c. The various rooms, laboratories and workshops are illustrated.

INCOME TAX CHARTS.—A sixth edition incorporating the changes made by the Finance Act of 1921, has just been published of Mr. C. H. Tolley's income-tax charts. These charts are published in the form of a folder in sections. Each section is devoted to one particular part of the tax, and gives the scales and regulations for the various years so that the charges can be readily compared, and the points of the present Act quickly grasped. The first section covers the rate of the tax, abatements, allowances, &c. The next deals with super tax rates; the third, with the incidence of the tax on foreigners, British non-residents, &c. Subsequent sections deal with the excess profits tax, corporation tax, annual returns, war allowances, and so on. In fact, the whole tax is sectionalised and the main points of each section brought out, with cross-references where necessary for a complete understanding of the provisions. The chart may be procured at 2*s.* 6*d.* net (post free 2*s.* 8*d.*) from the compiler, 4, Great Winchester-street, E.C. 2.

THE LATE SIR JOHN HAROLD HEFFERNAN.

THE death is announced, as having occurred on Saturday last, of Sir John Harold Hefferman, who was in his eighty-seventh year. Sir John was an almost lifelong friend of the late Lord Fisher, the two having served together in the Warrior, the first British ironclad. The son of the late Dr. Hefferman, of Carisbrooke, Isle of Wight, John Harold Hefferman became assistant engineer in the Royal Navy in 1855, receiving, while holding that rank, a gold medal in connection with the laying of the first Atlantic cable. He was promoted to the rank of engineer in 1861, and to that of chief engineer in 1868. After service on the North American station and elsewhere, he was appointed to the Inflexible, which commissioned in 1881 for the Mediterranean. This ship, it will be remembered, took a prominent part in the bombardment of Alexandria in 1882, and for his services in that connection and subsequently, John Hefferman was appointed to the rank of inspector of machinery, subsequently changed to engineer-captain. He received the Egyptian Medal, the Alexandria Clasp, and the Khedive's Bronze Star for his work in this war. His next appointment was that of chief engineer of Bermuda Dockyard. In 1885 Sir John was promoted to chief inspector of machinery (engineer rear-admiral) and was responsible for the machinery of ships of the Reserve.

In 1891 the honour of C.B. was conferred upon him, and in 1911 he had the distinction of being chosen as representative of the engineering branch of the Navy for the honour of K.C.B. awarded on the occasion of the Coronation of His Majesty King George. Sir John retired in 1892. His death occurred at the home of his daughter, at Burton-on-Trent.

THE CASTING OF BRASS INGOTS.*

By R. GENDERS, M.B.E., B.Met., A.I.C., Member (Woolwich). (Communication from the Research Department, Woolwich.)

DURING the examination of large numbers of specimens of hollow-drawn articles made from 70 : 30 brass rod, which were subjected to expansion of the walls in manufacture, and later in service, it was found that where failures occurred, whether during manufacture or in service, they were due almost exclusively to the presence of inclusions of non-metallic matter which must have originated in the casting of the ingot. The surface of the burst or split in the wall was generally discoloured or black, and transverse sections through portions below the split invariably disclosed the responsible defect. Such an inclusion, radial in direction and connected with cracks, is shown in Fig. 1 above.

It has been found that defects similar to those in articles made from rod by drawing, very seldom cause failure in tubes and similar articles, such as cartridge cases, which are drawn from a disc. This would not be unexpected. In the rolling of an ingot to rod any defects, such as inclusions of non-metallic matter, would be elongated to an extent depending on the relative cross-sections of the ingot and the rod. Laterally, the defects may have their largest dimension in any direction, depending on the original position in the ingot and the manner in which the rolling has been done, but there is no doubt that a large proportion of defects are approximately radial in the finished rod and remain so throughout manufacture. Non-metallic inclusions have no useful strength and, in their effect on the mechanical properties of the metal, amount practically to areas of discontinuity. Thus an inclusion, radial in the wall of a tube, reduces the effective thickness of the wall by an amount equal to its radial length, and further, probably acts as a notch from which a crack may start on expansion of the tube. When the ingot is made into strip by rolling, any defects present are elongated in the form of plates in planes parallel to the surfaces of the strip. In the cupping operations such defects would be also distorted into cup form, and finally drawn into the walls of the tube as thin plates running circumferentially and concentrically with the inside and outside surfaces. A defect running in this direction would be of little consequence as regards reduction of the effective thickness of the wall, and would be much less likely to serve as a nucleus for the starting of a crack.

The methods used in casting ingots of brass vary considerably in detail. Much consideration is given to the saving of rolling, and ingots are made in a correspondingly suitable form, those used for the making of rod commonly being very long and narrow.

Such forms are not particularly undesirable when the finished product is solid, but where a hollow article, subject to expanding stresses in use, is to be made, the avoidance of inclusions of foreign matter is vital, and the form of ingot requires considerable modification.

The long narrow ingot mould leads to splashing, and the solidification of the metal is very rapid, leaving no time for the rising of trapped dross, &c. The pipe forms rapidly and is steep and narrow, and the intermittent replenishment with molten metal during solidification results in the enclosing of the foreign matter on the surface of the previous depression. The solidification of the metal inwards from the sides of a rapidly filled parallel mould is practically uniform along the length, and shrinkage cavities are formed in the central region, due to lack of fluid metal to take up contraction when the metal below solidifies.

In experiments which were carried out to minimise the occurrence of non-metallic inclusions, the first step taken was to adopt a form of ingot whose length was not great in proportion to the cross-sectional area. The ingots made were 3 in. square and 30 in. in length, as compared with the ingots 6 ft. to 7 ft. in length and 1½ in. square section in common use. Steel-making practice was followed in introducing a hot sinking head or "dozzle." The dozzle (a short fireclay sleeve) is heated to the melting furnace temperature and inserted in the top of the mould, resting on a small ledge. A sketch showing the arrangement is given in Fig. 2. The molten brass is poured through the dozzle, which is filled to the top. No pipe is formed in the ingot proper, the metal in the dozzle remaining quite fluid and sinking gradually, with level surface, to feed the contraction of the ingot below. Additions of metal may be made at any time to the metal in the dozzle without risk of introducing defects into the ingot, any dross rising to the top of the still fluid head. The dozzle is thus an automatic feeder, ensuring that the top portion of the ingot is free from piping defects. There is no need to discard any of the top end of the ingot beyond the metal which has finally solidified in the dozzle. It was found later that these experiments were undertaken at about the same time as the introduction of dozzle feeding for flat cartridge case ingots by Barclay.

Central shrinkage cavities were avoided by regulating the rate of pouring so that the ingot, when just completely poured, had a fair temperature gradient from bottom to top. This necessitated a rate of pouring much below that for the normal foundry practice, and where two ingots were poured from one pot the cooling in the crucible of the metal for the second ingot was appreciable.

In order to overcome this difficulty the moulds were tapered, the top being enlarged by increasing amounts in successive experiments, and ingots were cast at the usual foundry speed. It was found that with a mould 3½ in. square at the top, tapering to 3 in. at the bottom, no shrinkage cavities were formed, and the ingot appeared to be practically perfect as regards soundness. The use of a tapered ingot results in either a tapered strip or the necessity for a certain amount of edge rolling. Its adoption, however, appears to be justified by the greater certainty with which sound ingots can be produced.

By these methods, failures which previously reached large percentages were reduced to practically nil. Wastage during manufacture was reduced from about 25 per cent. to a negligible figure.

A further refinement which the author would like to see adopted in non-ferrous foundries is the use of a ladle and bottom pouring. This method has been adopted with considerable success in one particular works, for the manufacture of articles in which non-metallic inclusions are to be avoided. It is fully recognised that in a great many cases economic considerations would render such methods as the use of short broad tapered ingots with dozzle feed beyond reach, but cases have come under the author's notice where, had it been recognised that the avoidance of non-metallic inclusions was of primary importance and the costlier methods adopted, such methods would undoubtedly have proved more economical than the endless replacement of wasters in manufacture and rejections.

FIG. 1. RADIAL NON-METALLIC INCLUSION IN WALL OF TUBE CONTINUOUS WITH A SPLIT (× 100).

Fig. 2. SHOWING POSITION OF "DOZZLE" IN TOP OF INGOT MOULD.

* Paper read at the Birmingham meeting of the Institute of Metals, Wednesday, September 21, 1921.

CHINESE OVERSEAS HOME INDUSTRY DEVELOPMENT COMMISSION.—The Chinese Overseas Home Industry Development Commission, initiated by two Chinese overseas merchants of Fukien, Hwang Yi-tau and Kwo Tsang-hai, is in process of organisation. It is planned to raise a capital of 150,000,000 dols. among Chinese overseas merchants for the purpose of undertaking manufacturing, banking, railway and shipping developments. The China and South Seas Bank is one of the subsidiary enterprises. Fukien, Kwangtung, Chekiang and Kiangsu will be the first fields of operation. A tea factory will be established in Fukien, a sugar factory in Kwangtung, a silk-spinning factory in Chekiang, and a cotton mill in Kiangsu. Messrs. Hwang and Kwo have been elected the representatives in China, while the chairmen and vice-chairmen of the Rangoon Chinese Chamber of Commerce, and the Manila Chinese Chamber of Commerce, are the representatives for the South Seas. Preparation bureaux have been opened at Shanghai and Amoy. This undertaking is the result of the recent invitation of the Government to overseas merchants to help in the development of their country.

THE PROPERTIES OF SOME NICKEL-ALUMINIUM-COPPER ALLOYS.*

By Professor A. A. READ, D.Met., Member (Cardiff), and R. H. GREAVES, M.Sc., Member (Woolwich).

THE present paper describes a continuation of the authors' former work on nickel-aluminium-copper alloys (see ENGINEERING, vol. xcvii, page 399).

The investigation of the constitutional diagram of these alloys presents numerous difficulties, and the authors' work in this direction is so incomplete that they wish to make only a passing reference to it. It is found, however, that the limiting aluminium content of the α solution at 900 deg. C. is only slightly affected by small quantities of nickel, but at ordinary temperatures it is very considerably reduced by nickel. Fig. 1 shows these limits approximately. Alloys in the region O A B Y consist only of α at 900 deg. C., and those in the region O E D C Y, only of α at ordinary temperatures.

It is with a few alloys of the region C D B, in which the α constituent undergoes a change on cooling, that the present paper deals.

Preparation of the Alloys.—Analyses of the materials used in preparing the alloys are given in the previous paper. Melting and casting of the ingots were carried out under the conditions identical with those employed previously. The larger ingots, which were rolled into rods, were 18 in. long and 2¼ in. in diameter, and weighed about 20 lb. Chill castings were made in pairs in chill moulds 10 in. long and 1 in. in diameter. The authors have again to express their thanks to Mr. A. H. Wolseley for supervising the rolling at the Fazeley-street Mills of Messrs. Clifford and Sons, Birmingham.

The ingots were heated to about 900 deg. C. and rolled hot down to $\frac{1}{16}$ in. diameter, then cold-rolled with 12 passes down to nearly $\frac{1}{8}$ in. diameter. About half of this rod was reheated and rolled hot to $\frac{9}{64}$ in. diameter, then cold-rolled with 12 passes to $\frac{1}{8}$ in. diameter. In addition, a short length of the rod was reheated and rolled hot to $\frac{1}{4}$ in. diameter. The material thus obtained consisted of cold-rolled rods of about $\frac{1}{8}$ in. and $\frac{1}{4}$ in. diameter, and hot-rolled rods of $\frac{1}{4}$ in. diameter.

On analysis the rods and chill castings gave the results shown in Table I. The composition of alloys Nos. 9 and 10 of the previous paper, on which some additional work was done, is also given. In addition, a number of exploratory alloys, some of which were referred to in the previous paper, were made in small quantities, hot forged and heat treated. Fig. 2 gives two Brinell hardness numbers for each of these alloys; the lower figure is the hardness of the alloy in the quenched condition, and the upper figure that of the slowly cooled alloy (900 deg. to 700 deg. in 25 to 35 minutes).

TABLE I.—*Composition of the Alloys.*

Form of Material.	No.	Copper per Cent.	Nickel per Cent.	Aluminium per Cent. by Difference.
Hot and cold-rolled rod	9	89·84	4·84	5·32
	10	87·48	7·31	5·21
	23	87·32	7·34	5·34
	24	87·45	4·64	7·91
	25	87·45	5·62	6·93
Chill castings	26	87·30	7·31	5·39
	27	85·18	6·94	7·88
	28	87·58	5·03	7·39
	29	87·16	6·22	6·62

All the alloys shown on the right of A B contain β as a constituent after quenching from 900 deg., and are softened by slow cooling. All the alloys given in Table I fall within the region C D B of Figs. 1 and 2; they consist of the α solid solution when quenched from 900 deg., and are hardened by slow cooling. The temperature at which separation of the hard constituent occurs in these alloys was determined by quenching and microscopical examination of small specimens, and is clearly indicated by hardness tests on this material. In Fig. 3 are plotted the Brinell hardness numbers of specimens which have been quenched from 900 deg. C., then reheated to various temperatures between 700 deg. and 900 deg. C., and again quenched in water. The hardening was accompanied in each case by separation of the special constituent.

Rolling and Machining.—A high temperature is required for hot-rolling these alloys; they were reported to be "hard," making them difficult to roll cold. The tests, however, show that they received a considerable amount of cold-work without injury. The ¼ in. diameter cold-rolled rod of No. 25 showed surface defects, which however did not interfere with the tests. With care Nos. 23 to 25 could be cold-rolled into strip, provided the necessary annealing was carried out at 900 deg. C. and followed by cooling in water or air. No. 24 behaved best under these conditions and No. 23 worst. The slowly cooled alloys cracked badly on cold-rolling.

All the alloys were very easy to machine. The hot and cold-rolled rod and the slowly cooled alloys turned well; the quenched alloys, being much softer and rather tough, required more care.

Tensile Tests and Determination of Yield Point.—Except in the case of the ¼-in. rod, tensile tests were made on test-pieces having the following dimensions:—

Diameter, 0·564 in. Gauge length, 2 in. Parallel, 2¼ in.

The dimensions of test-pieces from the ¼-in. rods were:—

Diameter, 0·356 in. Gauge length (for extensometer), 2 in.
Parallel, 2¼ in. Gauge length (for measurement of elongation), 1·27 in. (= 4 $\sqrt{a}$).

FIG. 1. APPROXIMATE LIMITS OF α SOLUTION AT 900 DEG. (AB) AND AT ATMOSPHERIC TEMPERATURE (CDE).

FIG. 2. BRINELL HARDNESS TESTS. UPPER FIGURE, AS SLOWLY COOLED FROM 900 DEG. C.; LOWER FIGURE, AS QUENCHED FROM 900 DEG. C.

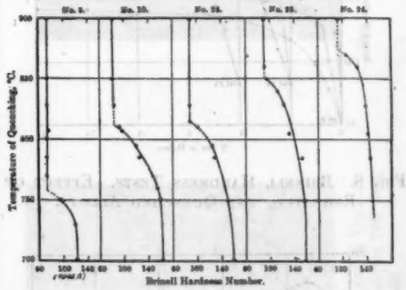


FIG. 3. BRINELL HARDNESS NUMBERS OF ALLOYS QUENCHED FROM 900 DEG., THEN REHEATED TO VARIOUS TEMPERATURES AND QUENCHED IN WATER.

Alloy No.	9	10	23	25	24
Nickel per cent.	4·84	7·31	7·34	5·62	4·64
Aluminium per cent.	5·32	5·21	5·34	6·93	7·91

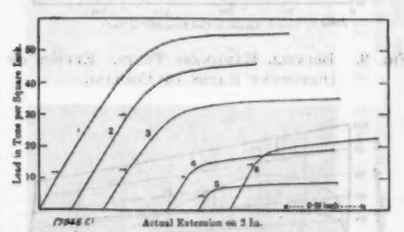


FIG. 4. LOAD EXTENSION DIAGRAMS OF ALLOY No. 25.

1. Cold-rolled rod, ¼ in. diameter.
2. Hot-rolled rod, ¼ in. diameter.
3. Cold-rolled rod, ⅛ in. diameter.
4. Slowly cooled from 900 deg. C.
5. Quenched from 900 deg. C.
6. Quenched from 900 deg., then reheated to 600 deg. for 2 hours and cooled in air.

The Ewing extensometer was used throughout. The tables contain the elastic limit (limit of proportionality), and the yield point defined as the load giving a permanent extension of ½ per cent. (0·01 in. on 2 in.). The yield points given in the previous paper referred to were in general those read off from Wicksteed autographic diagrams, but repetition of a number of these tests shows that the yield points there recorded are with a few exceptions almost identical with the load giving a permanent extension of ½ per cent.

In a later paper dealing with the light alloys of copper, nickel, and aluminium (see ENGINEERING, vol. xcix, page 342), the authors made a comparison of different methods of measuring the yield point, and found that the autographic diagram in this case also gave a yield point almost identical with the load giving a permanent extension of 0·01 in. on 2 in. The latter definition of yield point was not considered quite satisfactory on account of the marked creeping which occurred at that region of the load extension diagram, the time the load was held having a marked effect. In that investigation Scoble's method of determining yield point was adopted.

Since that date the use of a "proof load" to ensure a definite minimum yield point has come into common use. A line is scribed on the test-piece at a fixed radius from one of the gauge marks; after application of the "proof load" another line is scribed with the same centre and radius. A very usual condition is that the test-piece must support the proof load without undergoing a permanent extension of more than ¼ per cent. (i.e., 0·01 in. on 2 in.). For this reason the load giving a permanent extension of ¼ per cent. is recorded as the yield point in this paper.

A comparison has been made of different methods of measuring yield point in the case of 14 cold-rolled or heat-treated samples of these alloys, with the results given below:—

Load giving permanent extension of ¼ per cent.	minus	load giving permanent extension of ½ per cent.	varied from 0·4 to 1·3 tons per sq. in.
Load giving permanent extension of ¼ per cent.	minus	yield point by Scoble's method	varied from 0·6 to 2·5* tons per sq. in.
Load giving permanent extension of ¼ per cent.	minus	yield point by Scoble's method	varied from − 0·3 to + 1·6 † tons per sq. in.

* All figures above 1·3 were obtained with the slowly cooled alloys.

† All figures above 0·8 were obtained with the slowly cooled alloys.

Twenty-two samples of the light alloys (cold-drawn or annealed) gave:—

Load giving permanent extension of ¼ per cent.	minus	yield point by Scoble's method	varied from 0·2 to 1·6 tons per sq. in.

The authors consider a permissible extension of 0·01 in. at the proof load to be rather too big, for the reason given above, viz., that the time effect on material which is just yielding at the proof load may be serious. Moreover, in the case of definite doubling of the lines the question whether extension does or does not exceed 0·01 in. may cause dispute. They consider that the proof load should be so specified that any definite doubling of the scribed line after application of the proof load should constitute failure to pass the test. This would involve reduction of the proof load by 1 or 2 tons per square in., and the use of a yield point defined as the load giving ¼ per cent. extension. Scoble's method of determining the yield point gives similar results, but in some cases is even more severe.

Properties of the Cast Material.—Tensile tests and Brinell tests were made with a 10 mm. diameter ball under a load of 3,000 kg. on alloys as chill cast and after heat treatment. The hardness, yield point, and maximum load are considerably increased, with corresponding reduction of elongation by slow cooling after annealing, or by reheating to 700 deg. C.

The chill cast alloys consist of dendrites of the α constituent (Fig. 12, page 455). On annealing at 900 deg. the α becomes more homogeneous, but if the annealing is followed by slow cooling or if the alloy is reheated to 700 deg., separation of the second constituent occurs (Fig. 13, page 455).

The mechanical properties of a number of nickel-aluminium copper alloys in the cast condition were determined by L. Guillet. His third series, containing nearly 90 per cent. of copper with varying nickel and aluminium, includes compositions dealt with in this paper. He found that all alloys of this series with 0 to 7 per cent. aluminium (10 to 3 per cent. nickel) consisted in the cast condition of the α solid solution, the maximum hardness being obtained with 8 per cent. nickel and 2 per cent. aluminium. Quenching had no effect except on alloys containing β. He also refers to the high mechanical properties obtained by forging and annealing the alloy containing 2·5 per cent. aluminium and 15 per cent. nickel (viz., 49·4 tons per square in. maximum load with an elongation of 11 per cent., and Brinell hardness number 250), but made no further reference to heat treatment.

Properties of the Cold-Rolled Alloys.—Examination of the cold-rolled alloys was carried out mainly on rods ¼ in. in diameter. On account of the high temperatures required in rolling these alloys, the "hot-rolled" ¼ in. diameter rods actually had received more cold-work than cold-rolled rod of ⅛ in. diameter. The difference between the load-extension diagrams of the hot and cold-rolled material is illustrated in Fig. 4. Cold-rolled rod shows a gradual departure from proportionality at a low load, the hot-rolled rod shows a relatively high and

* Abstract of a paper read at the Birmingham meeting of the Institute of Metals, Wednesday, September 21, 1921.

distinct elastic limit, the temperature at which rolling was stopped having been sufficient to bring about recovery of the elastic properties.

The effect of heat-treatment on the cold-rolled alloys is shown in the paper by the results of mechanical tests made on a number of the ½ in. diameter rod of each of the alloys after annealing for ½ hour and other times, at different temperatures from 100 deg. C. to 800 deg. C. and cooling in air. The results of the ½-hour series are given in Fig. 5. After the above treatment the behaviour of alloy No. 24 was distinctly different from that of alloys Nos. 23 and 25, a difference which was confirmed by repeated tests. The load-extension diagrams for the series of ½-hour treatments on Nos. 23 and 24 are given in Figs. 6 and 7.

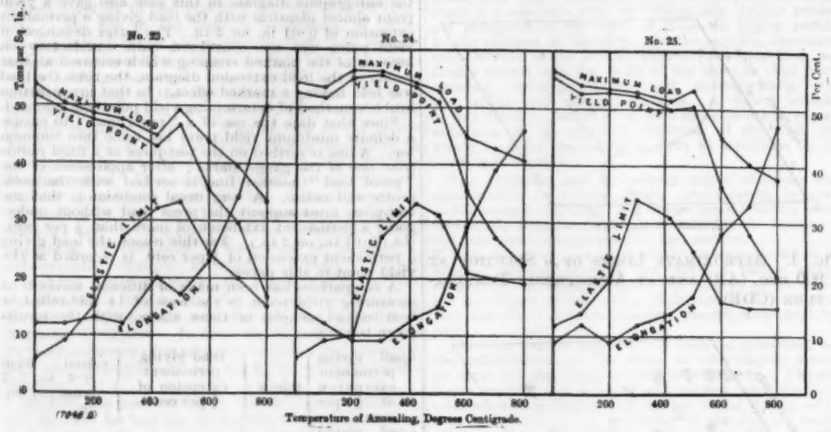


FIG. 5. TENSILE TESTS. EFFECT OF ANNEALING ON COLD-ROLLED ROD.

Alloy No.	23	24	25
Nickel per cent.	7·34	4·64	5·62
Aluminium per cent.	5·34	7·91	6·93

In all cases low-temperature annealing produced a rise in the limit of proportionality, but in the ½-hour period the treatment only became effective at temperatures between 300 deg. C. and 500 deg. C. In the case of alloy No. 24 the yield point and tensile strength showed a corresponding rise with maxima at about 300 deg. C.; in other cases both yield point and maximum load fell off continuously with rise of temperature, with the exception of a sharp upward tendency at 500 deg. C. This occurred in both alloys, and indications of it were also observed in No. 24.

The explanation of the difference of behaviour may be that Nos. 23 and 25 had approached more nearly to their condition of maximum hardening by cold-work than No. 24, and that softening therefore set in at very low temperatures. The ½ in. diameter rod of No. 25, which had received less cold-work, did not show any appreciable fall in tensile properties after annealing at 300 deg. C. Material was not available to carry out more complete tests in this connection.

The fairly rapid cooling which these alloys undergo during rolling suppresses the separation of the hard constituent. On reheating at 500 deg. C., separation of this constituent occurs concurrently with the partial re-crystallisation of *a* and confers additional hardness on the alloys at the moment when the normal softening is only proceeding very slowly (Fig. 14 opposite).

Properties of the Heat-Treated Alloys.—The heat-treatment applied consisted of (1) Quenching from 900 deg.; (2) cooling at various rates from 900 deg.; (3) quenching from 900 deg., followed by reheating to various temperatures below 800 deg. C.

Microstructure.—The structures of the quenched and air-cooled alloys consist of the *a* constituent only, showing twinning (Figs. 18 and 19). After slow cooling dark areas are observed at low magnification, cutting right across the *a* crystals (Fig. 15). In alloys with higher nickel this banding may be more pronounced and may completely mask the appearance of the *a* crystals (Fig. 20). In the transverse section an appearance of distorted dendritic crystals is observed (Fig. 16), an indication of the extremely slow rate of diffusion of nickel. On examination at high power the *a* grains are found to have assumed a granular structure, due to the separation of minute particles etching brown or blue in the golden yellow ground-mass of *a* (Fig. 22). The quantity and character of the separated constituent depends, however, on rate of cooling of the alloy. Reheating of the quenched alloy results in an exceedingly fine structure which it is scarcely possible to resolve, while that obtained after heating for three hours at 700 deg. C. (Fig. 21) represents the coarsest structure observed in the reheated alloys. Very slow cooling causes coalescence of the particles and separation in the grain boundaries (Figs. 17 and 23).

Hardness Tests.—A good indication of the effect of these treatments and the range of properties covered can be obtained from the results of hardness tests. Those given in the introductory section to this paper (Fig. 3) show the limiting temperatures at which the alloys consist wholly of *a* solid solution. Below these limiting temperatures separation of the special constituent occurs at a slower rate the lower the temperature. The rate of hardening of the alloys on reheating is illustrated by typical examples in Fig. 8. It is possible to produce greater hardness by this tempering treatment than by slow cooling alone unless the rate of cooling is carefully chosen. The effect of various rates of cooling from 900 deg. C. on the Brinell hardness number is shown in Fig. 9. Very slow rates of cooling give softer material than moderately slow rates, greater coalescence of the separating constituent occurring when the alloy is cooled very slowly.

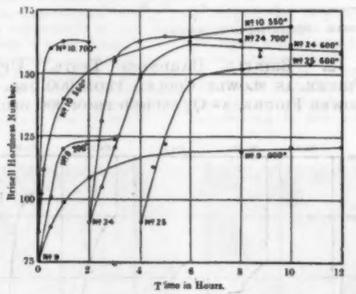


FIG. 8. BRINELL HARDNESS TESTS. EFFECT OF REHEATING THE QUENCHED ALLOYS.

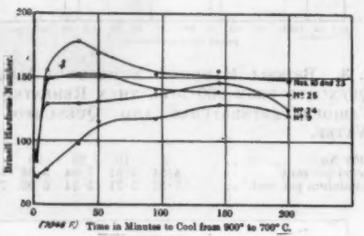


FIG. 9. BRINELL HARDNESS TESTS. EFFECT OF DIFFERENT RATES OF COOLING.

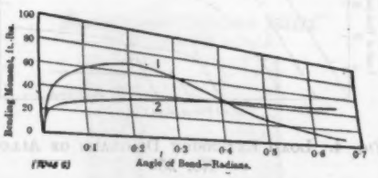


FIG. 10. SLOW BENDING TEST ON NOTCHED BARS. ALLOY NO. 25, SLOWLY COOLED FROM 900 DEG. (CURVE 1) AND QUENCHED FROM 900 DEG. (CURVE 2).

Tensile Tests.—Tensile tests were made on quickly and slowly cooled alloys, and the results were given in the paper, together with the results of similar tests on the ½ in. diameter rods quenched and reheated to various temperatures.

Notched-Bar Impact and Slow Bending Tests.—The difference between the quenched and slowly cooled alloys is clearly shown by notched-bar impact tests. Those given in the paper were carried out in the Charpy machine on the B.E.S.A. standard form of test-piece (½ mm. radius V-notch).

The hardening effect of 1 per cent. of nickel on the *a* solution (whether quenched or slowly cooled) is accompanied by an increase in elongation; it is also accompanied by an increase in the energy absorbed in bending or breaking a notched bar, and in all these alloys there is a close correspondence between energy absorbed in the Charpy test and elongation in the tensile test.

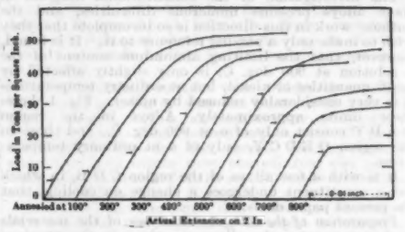


FIG. 6. LOAD EXTENSION DIAGRAMS OF ALLOY No. 23, COLD-ROLLED AND ANNEALED FOR ½ HOUR AT VARIOUS TEMPERATURES.

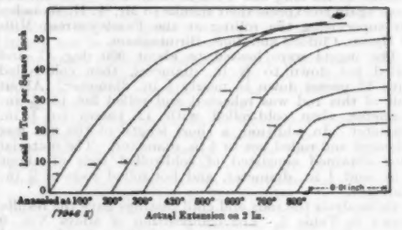


FIG. 7. LOAD EXTENSION DIAGRAMS OF ALLOY No. 24, COLD-ROLLED AND ANNEALED FOR ½ HOUR AT VARIOUS TEMPERATURES.

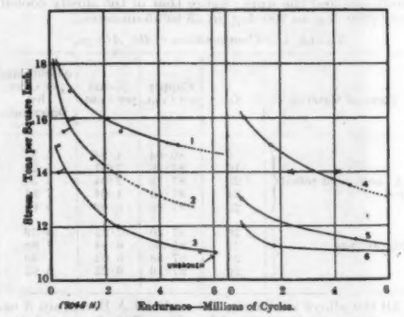


FIG. 11. ALTERNATING STRESS TESTS ON HEAT-TREATED ALLOYS.

Curve 1, No. 23. Quenched and reheated.
Curve 2, No. 25. Slowly cooled.
Curve 3, No. 25. Quenched.
Curve 4, No. 24. Quenched and reheated.
Curve 5, No. 24. Quenched (highest figures).
Curve 6, No. 24. Quenched (lowest figures).

Fig. 10 shows typical autographic diagrams given by these alloys in the Humfrey notched-bar slow bending machine. In the quenched alloys no crack is formed at the notch at the maximum bending angle attainable; in the slowly cooled alloy the material offers a steady resistance to the spread of the crack, as indicated by the gradual slope of the diagram after the maximum has been reached.

Alternating Stress Tests.—Determinations of limiting fatigue range under alternating stresses have been carried out on a selection of the alloys heat treated in the form of ½ in. diameter rods. These were kindly undertaken at the authors' request by Dr. B. P. Haigh, of the Royal Naval College, Greenwich, on his own form of alternating stress testing machine.

The principle of this machine and the results of numerous tests were described by Dr. Haigh in a paper to this Institute (see ENGINEERING, vol. civ, page 315), and the machine in its present form embodies some slight modifications and improvements on the design there referred to. Five tests at different ranges of stress were made with each heat-treated alloy. The results are plotted in Fig. 11.

The figures given as fatigue limits cannot be regarded as more than approximately correct, but the tests carried out are sufficient to reveal the behaviour of the

FIG. 12. No. 26. CHILL CAST. × 50.

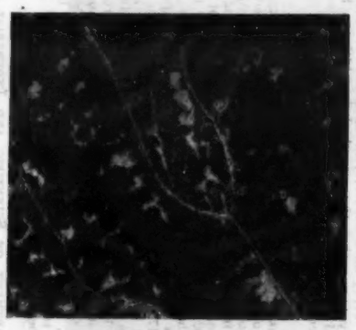


FIG. 13. No. 26. CHILL CASTING, ANNEALED AT 900 DEG. C. AND SLOWLY COOLED. × 100.

FIG. 14. No. 23. COLD ROLLED AND ANNEALED AT 500 DEG. C. FOR 2 HOURS. × 500.

FIG. 15. No. 9. SLOWLY COOLED FROM 900 DEG. C. LONGITUDINAL SECTION. × 50.

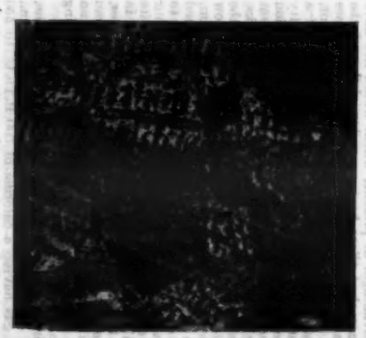


FIG. 16. No. 23. SLOWLY COOLED FROM 900 DEG. C. TRANSVERSE SECTION. × 100.

FIG. 17. No. 24. VERY SLOWLY COOLED FROM 900 DEG. C. (900 DEG. TO 700 DEG. IN 200 MINUTES). × 500.

FIG. 18. No. 25. QUENCHED FROM 900 DEG. C. × 100.

FIG. 19. No. 25. AIR-COOLED FROM 900 DEG. C. × 100.

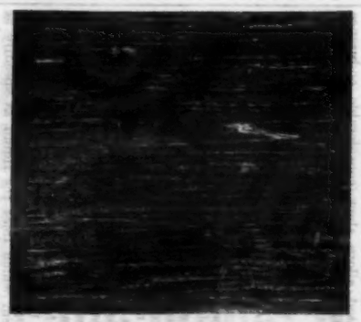


FIG. 20. No. 25. SLOWLY COOLED FROM 900 DEG. C. (900 DEG. TO 700 DEG. IN 35 MINUTES). × 50.

FIG. 21. No. 25. QUENCHED FROM 900 DEG. C., REHEATED TO 700 DEG. C. FOR 3 HOURS AND AIR-COOLED. × 500.

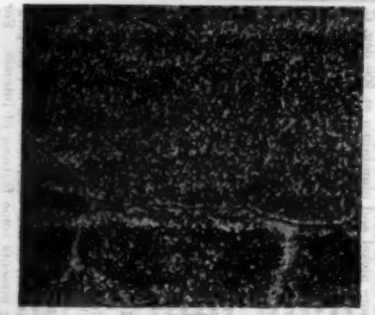


FIG. 22. No. 25. SLOWLY COOLED FROM 900 DEG. C. (900 DEG. TO 700 DEG. IN 35 MINUTES. SAME SPECIMEN AS FIG. 20). × 500.

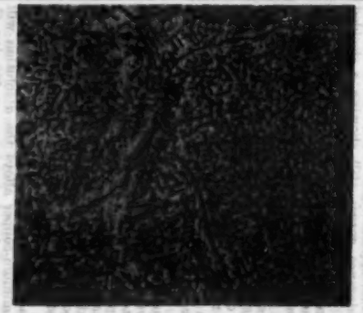


FIG. 23. No. 25. SLOWLY COOLED FROM 900 DEG. C. (900 DEG. TO 700 DEG. IN 145 MINUTES). × 500.

ETCHED WITH ACID FERRIC CHLORIDE SOLUTION.

alloys under alternating stress. Some features of interest in the results are :

1. All the alloys require prolonged application of alternating stress to determine the fatigue limit. They may remain unbroken after 3,000,000 or 4,000,000 alternations at stresses appreciably above their true fatigue limits, the endurance curves still showing a decided slope. Alloys of this type require testing to at least 6,000,000 alternations.

2. In the quenched alloys the fatigue limit is about 2 tons per square in. above the load giving a permanent extension of $\frac{1}{2}$ per square in. in the tensile test, and a considerable extension occurs in tension at stresses far below the fatigue limit. Such behaviour has previously been observed. The fact that it may occur detracts from the practical value of the test, since no such extension could be tolerated in any structure, even though it were known that ultimate failure would not occur.

3. In the quenched and reheated alloys the fatigue limit is not very different from the limit of proportionality in tension. These give the most regular results. The quenched alloys have a fatigue limit about 6 tons per square in. above the limit of proportionality in tension, and give the least regular series of results. The slowly cooled alloy is intermediate in behaviour, giving a fatigue limit a little above the elastic limit in tension.

Summary and Conclusions.—In some of the copper-rich nickel-aluminium-copper alloys the α solution will retain much more nickel and aluminium at 900 deg. C. than at ordinary temperatures. Alloys typical of the region comprised between the limits of composition of the α solution at 900 deg. and at ordinary temperatures have been examined. These alloys, while relatively soft on quenching from 900 deg., are hardened by slow cooling from that temperature or by reheating to lower temperatures. This change in properties is the result of the appearance of a new constituent (probably a nickel-aluminium-copper solid solution), the separation of which is accompanied by changes in the density and electrical conductivity of the alloy in addition to its effect on tensile, hardness, notched bar, and other tests.

The separation of this special constituent takes place somewhat slowly, so that chill-cast alloys and hot rolled rods of small section consist almost wholly of the α constituent. In this condition the alloys can be cold-rolled, though if cold-rolling of the slowly cooled alloys is attempted they crack badly. If annealing is required during cold-rolling the alloy must be heated to 900 deg. and cooled rapidly in air or water.

The cold-rolled rod, obtained by hot-rolling followed by a few passes in the cold, thus consists almost wholly of the α constituent, and its behaviour on low temperature annealing presents some features of interest. For complete restoration of the elastic limit in tension annealing for $\frac{1}{2}$ hour at 300 deg. C. to 500 deg. C. is required. This may or may not be accompanied by an increase in the maximum tensile strength according to the degree of cold-work to which the alloy has been subjected. In any case, softening proceeds very slowly up to 500 deg., at which temperature precipitation of the nickel-aluminium rich constituent begins to take place at an appreciable rate, with the result that with some compositions a progressive increase of hardness is obtained by holding the alloy at 500 deg. C. If the separation is sufficient this may more than counterbalance the previous softening, giving an alloy of high elastic limit and tensile strength, and good elongation (*e.g.*, a maximum load of over 50 tons per square in. with an elongation of 20 per cent.).

The rate of cooling from a temperature above that at which the α solution begins to deposit the special constituent has a great influence on the mechanical properties of the heat-treated alloys. The hardest product is, however, obtained by reheating the quenched alloy for some time at 600 deg. C. to 700 deg. C. (say, two hours at 600 deg., or $\frac{1}{2}$ hour at 700 deg.). The alloys so treated generally give better properties than are obtained by any uniform rate of slow cooling (*e.g.*, yield point over 20 tons per square in., maximum load over 40 tons per square in., elongation about 15 to 25 per cent.).

The fatigue limits to alternating stress are much higher than the tensile elastic limits in the quenched alloys, but in the quenched and tempered alloys they are approximately the same as the elastic limit in tension. The heat-treated alloys show considerable endurance under alternating stress above their true fatigue limit, the determination of which involved a number of prolonged tests.

POWER GAS FROM SEWAGE.*

By J. D. WATSON.

RECENT experiments at Birmingham have shown that it is practicable and economical to drive a suction gas engine with gas derived from sewage sludge. That organisms acting upon decaying vegetable matter have contributed to the formation of gas capable of being put to use is not unknown to the scientific world, but to employ gas emanating from sewage sludge to drive plant which forms an essential part in an installation for the purification of sewage is an achievement calculated to interest the economist.

In a sewerage district of 115 sq. miles it is evident that some of the sewage, particularly the solid matter contained in it, must undergo partial decomposition before reaching the outfall. It is obvious, therefore, that the system which frees the liquid as speedily as possible and subjects solids to intensive fermentation under strict control is an acceleration of Nature's methods, but it is not, as some have suggested, one of auto-digestion.

In 1904 the author called attention to the fact that foul sludge, which had attained a certain stage in Nature's putrefactive change, ceased to give off fœtid smell ; he did not attempt to explain the phenomenon, but the observation has confirmed the suggestion that the presence of H_2S rarely obtains unless the liquid portion of the sewage is also present. This observation was subsequently confirmed where Imhoff tanks were adopted in Germany and America, and it also accords with the experience gained at Parramatta in Australia.

The volume of wet sludge dealt with at Birmingham is not less than 400,000 tons per annum. Similar volumes are sent out to sea from Glasgow and Manchester, and correspondingly less from Dublin and Southampton ; but from London, not less than 2,000,000 tons are shipped out to Barrow Deep, 20 miles east of Southend, every year. The author estimates that from Birmingham alone 9,000 tons of dry solid matter are available to produce 320,000,000 cub. ft. of gas, which is equal to 16,000,000 h.p.-hours, taking 20 cub. ft. per brake horse-power hour, which is equivalent to 4,400 h.p. per day of 10 hours.

If one were to be guided by the yield of gas from sewage at Parramatta, these power estimates would be considerably higher, but, even after allowing for errors in calculations, the volumes of sludge capable of being gasified in our great cities are startling. What is possible in a climate like Australia, however, is not necessarily obtainable here, and the author has therefore confined himself to facts and experience obtained from

Fig. 1.

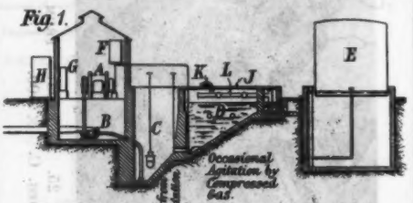
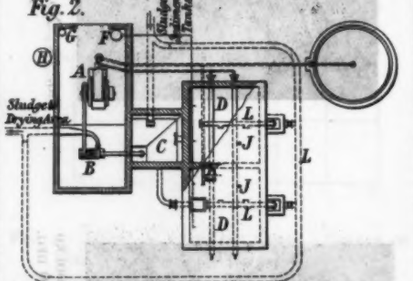


Fig. 2.



A	*34 (Max.) B.H.P. Gas Engine.*	*G*	*Compressed Air for Starting Engine.*
B	*Centrifugal Sludge Pump.*	*H*	*Cooling Tank.*
C	*Sludge Pump Well.*	*J*	*Relief Valves.*
D	*Gas Generating Tanks.*	*K*	*Gas Main.*
E	*Gas Holder.*	*L*	*Supply Pipes.*
F	*Compressed Gas Tank.*		

(9057)

Birmingham sewage, and the experimental station, shown diagrammatically in Figs. 1 and 2, forms part of an auxiliary works in course of construction at Cole Hall, where neither electric nor coal gas was available for power.

The pumping installation comprises a 34-b.h.p. horizontal gas engine of the ordinary suction type, made by the National Gas Engine Company, a 5-in. diameter centrifugal sludge pump, a sludge pump-well, two sludge digestion tanks for the generation of gas, and a gas-holder. The plant is designed to give 25 b.h.p. for a working period of 6 hours per day.

It should be observed that the plant is working under many disadvantages at present, which would not have been the case had there been more knowledge of the subject available when the plant was designed, and more confidence in the ultimate success of the experiment, *e.g.*, the gas-holder, which is an essential feature of a smooth working plant where gases of varying quantity have to be evenly diffused, is not yet erected ; its erection having been delayed until the result of the experiment justified the expense. Notwithstanding drawbacks, the material fact arising out of the experiment is the successful trial run of the engine and pump and the low cost of gas production. In speaking of the trial run, the makers of the engine state : "We naturally expected that adjustments and modifications would be required to the standard arrangement, but, to our surprise, our engineer was able to start up with the sewage gas quite satisfactorily within 5 minutes of the time he arrived in the engine house. After running light for a few minutes, the full load available was put on and the engine ran satisfactorily without further adjustments with an average of 60 to 70 explosions per minute, representing about 17 b.h.p. to 18 b.h.p."

The engine is the company's standard town-gas engine, capable of giving 34 b.h.p. (maximum) at 250 r.p.m., with town gas having a calorific of 500 B.Th.U. to 550 B.Th.U. per cubic foot, and, judging from the experience already obtained, there is every reason to expect gas of a higher calorific value, probably 650 B.Th.U. to 700 B.Th.U. Given a regular supply of gas perfectly satisfactory results are assured, and it may be assumed that the engine will require no more attention than the standard gas engine working on town gas. As a precaution, cams were provided ready to be fitted in case the calorific value was appreciably lower than anticipated and lower than that usually supplied to such engines from the Birmingham Corporation mains.

The makers state that the town gas usually consumed by an engine of this size is at the rate of 10,000 B.Th.U. per horse-power hour, and as the actual load given out was not less than 18 h.p., it is obvious that heat was supplied from the material available at the rate of at least 180,000 B.Th.U., or 1·8 therms per hour.

The following data are taken from the test run, to which the makers of the engine refer, although better runs were made subsequently : Morning :—Length of continuous run, 2½ hours ; indicated horse-power, maximum 27½, minimum 13, average 15 ; horse-power hours, 33. Afternoon :—Length of continuous run, 1½ hours ; indicated horse-power, maximum 32, minimum 20, average 24 ; horse-power hours, 30.

The principal constituents of sewage gas are methane, hydrogen, nitrogen and carbon dioxide, but it is the marsh gas or methane upon which we chiefly rely. The following statement gives the proportion of marsh gas found in various septic sewages in England, America, Australia and India :—

	Per Cent. Marsh Gas.
Exeter (Donald Cameron)	20·13
Exeter (Donald Cameron)	24·4
Matunga (C. C. James)	21·25
Matunga (C. C. James)	23·9
Lawrence (Mass. State Board of Health)—	
Septic tank A	79·0
Septic tank B	37·5
Septic tank F	78·9
Parramatta (Septic Gas Company of Australia)	60·0
Birmingham (J. D. Watson)	43·3

The majority of these results were obtained from septic sewage, but the author is of opinion that it is from sewage sludge, and not from liquid sewage, that a sufficient volume of gas can be obtained to render power from sewage reliable and economical ; particularly in this country where temperature is so variable and so frequently and persistently low. One of the remarkable features of the temporary engine-house shown in Figs. 1 and 2 is the entire absence of smell—good, bad or indifferent. On reflection, this may be no more than one would expect, as the gas forming the explosive mixture is chiefly methane mixed with atmospheric air in the proportion of 1 to 6 or 1 to 8, depending on the quality of the gas.

The author submits this communication to prove that it is practicable and, where the conditions are favourable, economical to utilise gas emanating from sewage to drive an ordinary suction gas engine. It is too early to dogmatise upon what are the most favourable conditions, but the Birmingham case shows that it is not necessary to possess the climate of India or Australia to obtain power gas from sewage, and he submits that it is the duty of every local authority in these days of enforced economy to see that the gas which has hitherto been disposed of as something which is of less than no value is utilised when possible and practicable.

* Paper read before Section G of the British Association, at Edinburgh, on September 14, 1921.

BRITISH PRODUCTION OF PIG-IRON AND STEEL.—The production of pig-iron in August amounted to 93,600 tons, compared with 10,200 tons in July. The output in March, the month immediately preceding the coal stoppage, was 386,000 tons, and in August of last year 752,400 tons, which was the record monthly total since the war. The production of steel ingots and castings in August amounted to 432,600 tons, compared with 117,200 tons in July, 359,100 tons in March, and 709,200 tons in August, 1920. The number of blast furnaces in operation at the end of August was 46, as against 15 at the end of July. The number in operation immediately before the coal stoppage was 109, and in August of last year 303. Of the pig-iron produced in August, 30,200 tons were hematite, 24,400 tons basic 28,500 tons foundry, 8,500 tons forge and 2,000 tons of "other qualities."

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.—A special series of reports is being published for this department in order to render available for the benefit of the industries concerned, results of scientific and industrial value contained in the technical records of the Department of Explosives Supply Ministry of Munitions. The work recorded was done at, or in, connection with some of the national factories during the war. The preparation of the abstracts and information was begun by the Ministry of Munitions at the close of the war, and arrangements have recently been made by the department to complete them. The first report in this series, "Recovery of Sulphuric and Nitric Acids from Acids used in the Manufacture of Explosives, Denitration and Absorption," has already been published by H.M. Stationery Office, and copies may be obtained, price 12*s.* 6*d.* (by post 13*s.*) from the addresses given below. The report "Manufacture of Trinitrotoluene (T.N.T.) and its Intermediate products" is divided into : Section I, History of Manufacture ; Section 2, Plant and Process for the Manufacture of T.N.T. ; Section 3, Plant and Process for the Manufacture of 2 : 4—Denitrotoluene. Owing to the cost of this volume, no copies are available for free distribution by the department. Copies, price 17*s.* 6*d.* (by post 18*s.*), may be obtained through any bookseller or directly from H.M. Stationery Office, at the following addresses : Imperial House, Kingsway, London, W.C. 2, or from E. Ponsonby, Limited, 116, Grafton-street, Dublin.

IRON BACTERIA IN RELATION TO THE INCRUSTATION OF PIPES.*

By Dr. DAVID ELLIS, Royal Technical College, Glasgow.

IRON BACTERIA occur normally in water reservoirs, and predominate in the conduits of these reservoirs. They do no harm in the sense that they give rise to toxic products; but occasionally they multiply in an extraordinary manner and render the water unfit to drink. Even this water cannot be regarded as poisonous, and I do not propose to deal here with these sudden visitations which are temporary but very disconcerting while they last.

The problem of greatest interest to engineers in this connection lies in the gradual diminution in the bore of the pipes, to an extent which causes the flow of water to be sensibly diminished. Cases have been known in which the pipe has become completely blocked up. Under these circumstances the biologist can render service to the engineer, for it is his business to index organisms, to study their life histories and apply his results, if possible to the elucidation of practical problems. The author has been engaged more or less for the last twelve years in studying iron bacteria from all parts of the world, and has recently embodied the results of his work in book form.

The five species of iron bacteria with which the water engineer should be either directly or indirectly acquainted are:—

Leptothrix ochracea (Kützing), Fig. 1.
Gallionella ferruginea (Ehrenberg), Fig. 5.
Cladothrix dichotoma (Cohn), Fig. 2.
Crenothrix polyspora (Cohn), Fig. 3.
Spirophyllum ferrugenium (Ellis), Fig. 4.

All five are found in this country. Typical examples are illustrated in Figs. 1 to 5.

The Physiology of Iron Bacteria.—After the identification of the iron bacteria, the next step is to deal with the conditions under which they live so as to be able to combat at the source the evil results which are brought about by their multiplication. The history of this part of the subject cannot be likened to a slowly dawning light. At one time in fact the light was completely extinguished through the widespread credence given to the statements of a mistaken but distinguished bacteriologist. There is no time in a short paper to traverse the whole subject, and it must suffice to state that out of the controversy has emerged the salient fact that the iron bacteria are saprophytes, and as such require organic food for their nutriment. The question for each water engineer to determine, therefore, is whether the water which is under his care contains enough organic matter to supply these needs. The amount of this organic matter should be determined by bacteriological, not chemical analysis, on account of the greater delicacy of the former method of testing. Further, he must ascertain whether the mineral ingredients in the water are such as to favour the growth of the iron bacteria. All organisms require mineral as well as organic constituents, but the nature of the minerals required varies considerably with different classes of organisms.

The second fact which has emerged from a study of the physiology of the iron bacteria is that acid waters are more favourable to the iron bacteria than alkaline waters in which the chief salts in solution are compounds of sodium and potassium, or soft siliceous waters such as are found, for example, in the Manchester water supply.

The third fact is one the importance of which has only lately been realised. It is that iron bacteria can and do multiply independently of the presence of iron. They are not iron bacteria in the sense that iron is a necessary part of their food, but if they do multiply in the presence of iron they are capable of furthering the oxidation of ferrous to ferric compounds. This, however, is an incidental, and not an essential, feature in their metabolism.

With these three cardinal facts in our minds I propose next to examine the different factors which interfere with the free flow of water as it leaves a reservoir, and also with the growth of the iron bacteria in the reservoir itself. Practical problems centre round four different kinds of growths.

I. *Slimy Streamers.*—These streamers appear on the walls and the bottom—if the water is shallow—of storage reservoirs. They are also found as streamers attached to the internal surface of the conduit pipes.

II. *Tubercular Incrustations.*—These are nodular excrescences on the pipes. When they become confluent they seriously interfere with the flow of the water.

III. *Iron Incrustations* on non-ferruginous surfaces. The walls themselves are not corroded in any way.

IV. *Spongey Disease of Cast-Iron.*

I. The slimy ferruginous streamers owe their existence entirely to the activities of iron bacteria and other organisms of a similar mode of life. Gallionella and Spirophyllum are the organisms chiefly concerned in the formation of these slimy streamers. Although the amount of iron in the water is roughly only one part in a million the unceasing accumulation of small amounts ultimately ends in large quantities being collected in the streamers. The mucilaginous degeneration of the cell-walls of iron bacteria furnishes the matrix in which the liberated iron can collect. When this mass of organisms dies their dead bodies furnish an additional amount of organic matter to serve as the basis for the organic supply of the next generation.

II. The occurrence of ferruginous tubercles is very common. The familiar limpet-like structures on the inner surface of the iron pipes are too familiar to need description. The formation of these tubercles may, and does take place in the complete absence of the iron bacteria or any other organisms. The biologist has to determine whether organisms influence the process when they are present. It must be pointed out that the formation of tubercles is dependent on the presence of CO_2 in the water. The author has repeatedly obtained iron bacteria from such tubercles. The influence of iron bacteria is thus accelerative rather than causative, inasmuch as they enrich the immediate neighbourhood of a tubercle with CO_2 and thus accelerate a chemical process which would take place in any case even if the iron bacteria were absent.

III. The incrustations that form on non-ferruginous surfaces must obviously obtain their iron from the water, and are entirely due to iron bacteria. Both here and on the Continent Gallionella is implicated.

IV. It is not proposed now to deal with the spongey disease of iron as the iron bacteria are not in any way guilty of causing this.

Remedies.—Each water supply must be considered on its own merits. The removal of slimy streamers must be governed by our knowledge of the iron bacteria. It must first be ascertained that the organisms concerned are iron bacteria. If this is proved it becomes the duty of the water engineer to remove, if possible, every factor which is favourable to the life of such bacteria. The most obvious method is, of course, the removal of organic matter from the water. This can be done by aeration, by the growth of green plants, by encouraging the action of nitrifying bacteria on filters, and by the use of animals which feed on the organic matter on the surfaces. The secret of Nature in getting rid of organic contamination is complete oxidation, and man cannot do better than copy Nature's example.

If the organic matter can be removed or oxidised there will be very little material upon which the iron bacteria can subsist. Acid waters are worse than those whose reaction is non-acid. The exact effect of various mineral salts on these organisms is not yet fully understood, but anything tending to reduce the acidity will also diminish the power of the bacteria to do harm. In the past attention was concentrated on the iron-content of the water, but it is now certain that the attention of the water engineer should be concentrated on the organic matter. He should further ascertain whether the gathering ground is sufficiently protected from organic contamination. When he has done all that is possible in these directions the proportion of iron in his water of one in a million parts need not cause any feeling of alarm. It seems to be clearly established that iron in the ferrous form is combined with the organic radicle upon which the bacteria feed, and that it is the digestion of the organic matter which begins the oxidation. By the removal of the organic matter a good part of the offending iron will also necessarily be removed. This is an additional reason for tackling the question of the organic matter.

There should be periodical biological as well as chemical tests for all water supply reservoirs. Tests should be conducted periodically to determine,

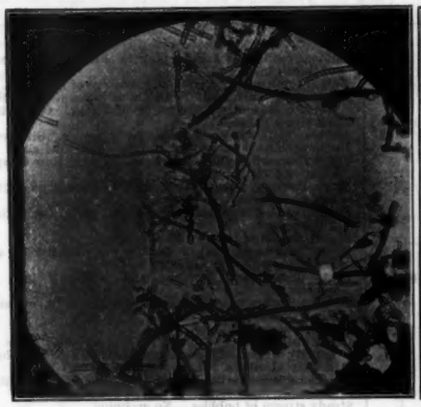


FIG. 1. CHIEFLY LEPTOTHRIX, ONE OR TWO OF SPIROPHYLLUM.

FIG. 2. CLADOTHRIX DICHOTOMA.

FIG. 3. CRENOTHRIX POLYSPORA.

FIG. 4. SPIROPHYLLUM.

FIG. 5. GALLIONELLA FERRUGINEA.

* Paper read before Section G of the British Association, at Edinburgh, September 14, 1921.

(1) The amount of organic matter as measured by the number of bacteria per cubic centimetre that the water can support.
(2) The acidity of the water.
(3) The organisms that are established in the reservoirs and conduits; and particularly the iron bacteria that are normally present in the conduits.

EXPERIMENTS ON AIR LIFT PUMPING.*

By Dr. JOHN S. OWENS, B.A.

THE author's purpose in the present paper is rather to call attention to the possibilities of the air-lift pump than to indicate any final conclusions as to the best design of such pumps. The results of past experience of air lifts have shown that the air lift is usually an extremely wasteful method of pumping, owing to its low efficiency. This has militated against its extended use, and it appeared to the author that if the low efficiency could be overcome there would be an immense field for the use of such pumps. It is hoped, therefore, to stimulate interest and promote investigation by setting forth the few and rather incomplete researches referred to in this paper. The experiments described were made with a view to ascertaining the most efficient design for an air-lift pump, for lifting acid mine liquors in the mine of San Domingos, in the South of Portugal. In the latter part of the paper the installation finally adopted is described, and lists of tests given showing that it is quite possible to get pump efficiencies with air lifts of between 60 per cent. and 70 per cent.

A study of the work already done on air-lift pumping convinced the author that the low efficiencies usually obtained were not an essential part of the method. For example, in a series of tests described by J. Kelly in 1906,† the "efficiency between work in water raised and indicated horse-power in air cylinders" of the compressor, ranges between 9·93 and 41·2 in a group of 63 tests, the average efficiency being about 25 per cent. In a table of tests given in the same paper by Professor Josse, the efficiency on the same basis varied between 25·6 per cent. and 44·5 per cent. Again, in a paper by A. W. Purchas, published in 1912–13,‡ out of a group of 12 tests, the efficiency measured as between water horse-power and air horse-power, ranged between 22·5 per cent. and 36 per cent. In a large number of other tests examined, the efficiency rarely rose above 30 per cent. Professor Elmo G. Harris, in "Compressed Air," states that an efficiency of 45 per cent. was obtained in a well at Rolla, Mo., which was so piped that an initial velocity of 9·5 ft. and a discharge velocity of 22 ft. per second were obtained. "This is indeed a remarkably high efficiency, the lift considered, and, in fact, is considerably higher than any the writer has found under similar conditions." It will thus be seen that to expect an efficiency from an air lift pump of 45 per cent. is regarded as very optimistic. The causes of loss in air-lift pumps may be grouped under the following heads:—

1. Slippage losses, due to relative motion between air bubbles and water.
2. Losses due to friction of the mixture of air and water in the rising main.
3. Friction losses incurred by the flow of water before air is admitted.
4. Energy discharged in the kinetic form with the water and due to the velocity of discharge.

The losses under headings 3 and 4 are definite quantities and may be said to be more or less under control. It is in connection with those under 1 and 2, that there appears to be a good opportunity for increased economy.

Many experiments have been made already dealing with the question of submergence, and it has been definitely established that there is a most suitable value for this, the best efficiency being obtained with a submergence of about 70 per cent., that is, when the length of submerged pipe is 70 per cent. of the total length—submergence + lift. It is, therefore, not the author's intention to devote much space to this aspect of the subject.

The paper is divided into the following heads:—

A. A short consideration of the causes of loss and possible remedies.

B. A description of experiments made to elucidate causes of loss, and obtain data for improvements.

C. A description of the air-lift pump referred to at the beginning of this paper.

A. SOURCES OF LOSS.

Slippage.—It is now generally accepted that the air lift depends for its operation upon the fact that a mixture of air bubbles and water is lighter than pure water. Thus, if a suitable lift is not exceeded, when the water in the rising main, or eduction pipe, is kept aerated, or mixed with air bubbles, it will be continually forced upwards by the unbalanced part of the weight of a column of water of a height equal to the submergence, or depth below the water level at which air is admitted to the eduction pipe. The force operating at any given moment to cause a flow of water out of the eduction pipe will therefore be equal to the difference between the weight of the mixture in the eduction pipe and the weight of the column of solid water between the level of the air inlet and the water surface. During the operation of an air lift, the mixture of air bubbles and water is moving rapidly through the eduction pipe, at the same time each air bubble is moving upwards through the water with a velocity due to the action of a force equal to the difference between the weight of air enclosed and the weight of water displaced; practically, this means a force equal to the weight of a volume of water the size of the bubble. Other conditions remaining the same, a bubble should rise at the same velocity as a sphere of specific gravity = 2, would sink. Owing to the relative velocity of the bubbles through the water, it is theoretically possible that, when a suitable quantity of air is admitted, the water in the eduction pipe may be raised to the discharge level and maintained there without flow of water. This condition requires the flow of air into the water to be just balanced by the flow of air out of the water at the top, and under these circumstances no useful work would be done, while a certain quantity of air would be used. The condition would be very unstable and could hardly be maintained in practice. It is mentioned, however, as indicating theoretically the possibility of a state in which the whole of the energy in the air is dissipated in slippage without any useful work being done. During the operation of the air lift there must always be a loss due to this upward relative velocity of the bubbles through the water, and it is clearly advisable that, so far as it is under control, this relative velocity should be reduced to a minimum. To do this, the bubbles of air should be kept as small as possible, not only at the inlet, but also throughout their journey up the eduction pipe. It has not been, however, possible so far to reduce the bubbles below a ¼ in. to 1 in., or more, in diameter.

Returning to the loss arising from slippage, if we suppose the eduction pipe to be 100 ft. long, and that each bubble during its passage up the pipe slips through the water a distance of 10 ft., it would seem, at first sight, that the loss from slippage must be at least 10 per cent. Doubtless, however, some of this 10 per cent. of energy is communicated to the water by the air in its efforts to rise, and, as will be referred to later, it is probable that much of the loss included under "friction" of the mixture is due to eddy formation in the wake of the rising bubbles. If the bubbles have a definite motion relative to the water the distance they will slip through the water will depend upon the time available, i.e., the time they are in the eduction pipe, and thus, so far as slippage losses are concerned, a high velocity of the mixture tends towards a low slippage loss.

Friction.—Leaving for the present the question of friction of the water before arriving at the foot-piece, it is probable that one of the greatest sources of loss arises from so-called friction of the mixture in the eduction pipe. The losses due to fluid friction vary directly with the square of the velocity, while the losses referred to above from slippage, vary inversely as the velocity. Clearly, there should be a definite value for the velocity through the eduction pipe, where the sum of the friction and slippage losses will be a minimum. It is a well-established characteristic of air-lift pumps that the highest efficiency is developed at one particular delivery. That the term "friction" when applied to a mixture of air and water covers something more than ordinary fluid friction, is clear from the fact that, as pointed out by Gibson, the coefficient of friction has a value approximately six times that obtained for the flow of water alone at the same velocity. Using the following formula for the head lost in friction, as measured in feet of a

TABLE I.—EXPERIMENTAL RESULTS.

Experiment No.	Nozzle. No.	Nozzle. Diameter, In.	Flow of Air, Cub. Ft. Free Air per Minute.	Mean Velocity of Rise of Bubbles.	Diameter of Bubbles.	Remarks.
				ft.	in.	
1	0	0·15	Not measured	0·78	¼	Bubbles oscillating and keeping to side of tube. Average of three runs.
2	0	0·15	„	0·775	¼	Bubbles emitted, 1 per second. Average of five runs.
3	0	0·15	„	1·0	¼	Air supply increased. Continuous stream of bubbles. These collected into groups as they rose. Group timed, not single bubble.
4	1	0·034	„	0·75	¼ to ½	Bubbles emitted in groups followed by pauses. Sizes varied.
5	1	0·034	„	0·75	¼	Bubbles emitted in regular stream. All same size. Rate 1 per second, oscillating at 4 per second. Rose in spirals right and left handed.
6	1	0·034	0·00077	0·75	1/16	Single bubbles, 4 per second, visibly flattened. Oscillating at 4 per second.
7	1	0·034	Not measured	0·75	1/16	Single bubbles, 1 in 5 seconds, visibly flat. Oscillating at 4 per second.
8	1	0·034	0·0068	—	1/16	Steady stream of bubbles, 20 per second.
9	1	0·034	0·0176	1·10	1/16	Great disturbance in tube. Bubbles flattened, darting about and grouping. Very difficult to time.
10	1	0·034	0·034	—	Up to 1	Great disturbance, grouping and coalescing into large bubbles.
11	2	0·08	—	0·75	1/16	Bubbles oscillating, slightly flattened. Slow stream of 2 per second.
12	2	0·08	0·0093	0·87	¼	Rapid stream of bubbles.
13	2	0·08	0·0196	—	¼	Great disturbance. Bubbles coalescing. Could not time velocity of rise, but it was more rapid and bubbles following in wake of others. Much grouping.
14	2	0·08	0·0146	—	1/16	Considerable disturbance and bubbles darting about and coalescing just beginning. Much grouping.
15	2	0·08	0·0093	—	¼	Steady stream of bubbles. No grouping.
16	2	0·08	0·0365	—	¼	Grouping of bubbles and coalescing to form large ones.
17	3	0·136	—	0·77	1/16	Steady slow stream of bubbles.
18	3	0·136	0·0093	1·00	¼ to ½	Steady stream of bubbles delivered. Grouping. Rapid rise due to grouping.
19	3	0·136	0·0043	—	¼	Steady stream. Grouping beginning.
20	3	0·136	0·0256	—	½ down	Great disturbance. Grouping and coalescing
21	5	0·375	—	0·73	½	Large flattened single bubbles. U-tube not filled with air.
22	5	0·375	—	1·00	½	Bubbles grouping. U-tube not filled with air.
23	5	0·375	0·0365	1·33	1 down	Large bubbles forming by coalescing, then breaking up Great disturbance. Velocity of groups timed.
24	6	—	—	0·80	¼ to 1/16	Flow of air very slow, groups of mixed sized bubbles rose with very slight difference in velocity of different-sized bubbles. All oscillating rapidly, the small more rapidly than the large.
25	6 Cloth covered	—	0·0232	0·80	¼ to 1/16	Steady stream. No grouping. Nozzle covered with linen.
26	4	0·312	—	0·80	1/16	Bubbles emitted at about 1 per second. Did not fill orifice, but came out of upper part.
27	4	0·312	0·0127	—	—	Grouping of bubbles and coalescing beginning.
28	4	0·312	0·0465	—	—	Great disturbance, bubbles coalescing and breaking up again.

TABLE II.—TABLE OF EXPERIMENTS ON EFFECT OF SURFACE TENSION.

Experiment No.	Nozzle. No.	Nozzle. No. of Holes.	Nozzle. Diameter of Holes.	Flow of Air, Cub. Ft. Free Air per Minute.	Nature of Bubble Emission.	Excess Pressure in Inches of Water Required Above Head. To Start Flow of Bubbles.	Excess Pressure in Inches of Water Required Above Head. During Flow.	Head of Water Above Orifice.	Temperature of Water, Deg. F.	Remarks.
			in.					ft. in.		
29	7	8	0·032	—	Steady flow of ½ in. and 1/16 in. bubbles	1·5	1·25	2 8	57	Steady stream emitted during flow.
30	7	8	0·0635	0·0146	Steady stream, bubbles up to ½ in. diameter	0·75	0·50	2 8	57	Bubbles grouping and coalescing.
31	7	1	0·125	—	1/16 in. and ½ in.	0·36	0·26	1 0	71	Pulsating flow of bubbles. Groups of six emitted every 5 seconds.
32	7	1	0·25	Varied during experiment	Groups of three or more bubbles of graduated diameter, 1/16 in. to ½ in.	0·10	0·00	4 0	60	Groups of bubbles emitted at regular intervals until two groups per second emitted. Further increase of air caused continuous flow.

* Paper read before Section G of the British Association, at Edinburgh, September 14, 1921.

† Min. Proc. Inst.C.E., Vol. clxiii.

‡ Min. Proc. Inst.C.E., Vol. cxciii.

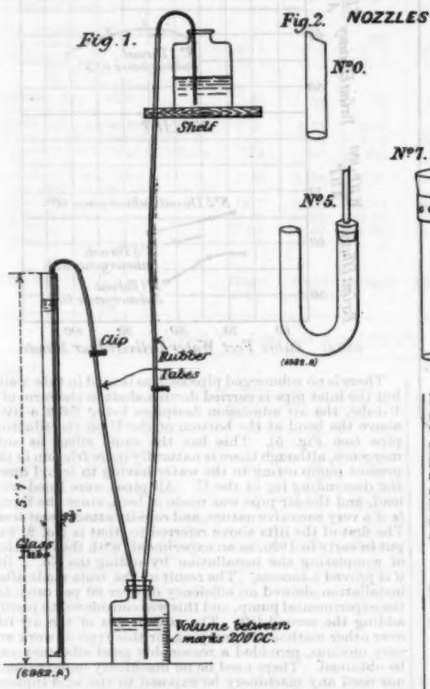
column of the mixture, and calling this h, Gibson* gives the relation :

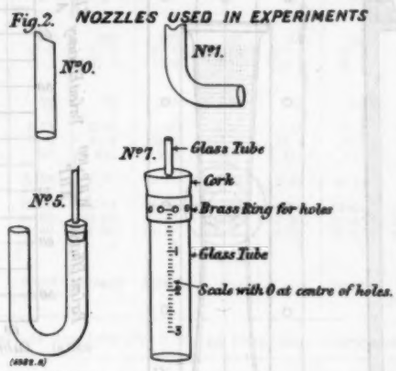
$$h = f\frac{(h_d + h_s)\,v^2}{2\,gm}$$

Where v = mean square of the velocity in the pipe, f is the coefficient of friction, h_d the lift in feet, h_s submergence in feet, and m the hydraulic mean depth, which, for a circular pipe, equals $\frac{d}{4}$. The value of f for a mixture is given by Gibson as 0·033, for 3-in. pipes with a mean velocity of 12·16 f.s. to 0·023 in a 12-in. pipe with $v = 6{\cdot}5$ f.s. Taking the results of tests referred to later in this paper, the author has calculated the coefficient of friction and obtained a value of $f = 0{\cdot}025$ in a 6¼-in. pipe with v mean = 13·3. It must, however, be noted that in this case friction losses include all losses except slippage losses, friction losses before the water arrived at the foot-piece, and losses in kinetic energy of discharge.

Kinetic Energy of Discharge.—It is unnecessary to do much more than refer briefly to the well-known fact that a fair amount of energy may be lost by delivering the water at too high a velocity. This is, however, easy to avoid by using a conical, or trumpet-shaped expanding mouthpiece to the delivery pipe.

Submergence.—The most suitable value for the submergence is best found experimentally, but it seems usually to lie between 65 per cent. and 75 per cent. The point to be kept in mind at the moment is simply that the relation of submergence to lift has an important bearing on the efficiency, and it will be noted that, in some of the tests given later in this paper, there is an appreciable effect to be obtained by even small variations in submergence.





B. EXPERIMENTS.

It was decided to examine experimentally the relation of diameter of bubble to velocity of rise through the water, and the conditions governing the size of the bubbles; such as the effect of diameter of orifice delivering air, and rate of flow of air. An apparatus was fixed up as illustrated in Fig. 1. This consisted of a 2½-in. diameter glass tube which could be filled with water, a bottle, shown near the bottom of the tube, which could be used to deliver compressed air, and to measure the rate of such delivery by means of the rise of water level in the bottle, read from a scale as shown. Water was admitted to the lower bottle from a vessel placed about 2 ft. above the top of the tube. By means of a long glass tube, attached by rubber tubing to the lower bottle, it was possible to emit bubbles of air at any desired rate into the water at the bottom of the large tube, and observe their behaviour on rising. By means of a stop-watch the velocity of rise through the water was measured in each case. Different nozzles for emitting air were fixed on the lower end of the small glass tube so as to examine their effect. A large number of experiments were made with this apparatus. Some of the results are shown in Tables I, II and III, on page 458, and annexed. It is to be noted that the diameters given for the bubbles, especially in Table I, are not exact, but estimated, and in some cases the estimate checked by counting the number of bubbles emitted while a measured volume of air was discharged; the diameters may, however, be regarded as very approximate in Tables I and II, and more accurate in Table III.

* "Hydraulics," page 703.

Size of Bubbles and Orifice Diameter.—Referring now to Table I, the first series of experiments was made chiefly to ascertain the effect of nozzle diameter on size of bubble. It will be observed that within the limit examined the effect of nozzle diameter was very slight. In experiments 1 to 20, nozzles varying from 0·034 in. to 0·136 in. diameter gave practically the same size of bubbles. On the other hand, the governing factor appeared to be the rate of flow of air through the orifice.

List of Nozzles Used. (*See* Fig. 2.)

No.
0. Plain glass tube, orifice in horizontal plane downwards. Diameter of orifice, 0·15 in.
1. Right angle bend glass tube, plane of orifice vertical. Diameter of tube, 0·15 in. Diameter of orifice, 0·034 in.
2. As 1, but diameter of orifice 0·090 in.
3. As 1, but diameter of orifice 0·136 in.
4. As 1, but diameter of orifice 0·312 in.
5. U-tube, orifice in horisontal plane, but opening facing upwards. Diameter, 0·375 in.
6. As 4, but orifice closed by piece of linen with fine openings between strands, about 0·004 in. × 0·016 in.

In the first experiments a clip was put on the water supply tube to the lower bottle, to regulate the flow of air by means of the flow of water (Fig. 1). It was found that with this arrangement when the rate of flow of air was gradually reduced, a point was soon reached when instead of a continuous stream of bubbles, pulsations commenced; a group of 20 or 30 bubbles being emitted, followed by a pause, as follows :—

Flow 2 seconds	...	Pause 15 seconds.
Flow 2 seconds	...	Pause 8 seconds.
Flow 1½ seconds	...	Pause 9 seconds.

With a slightly increased flow of air the intervals were :—

Flow 4 seconds	...	Pause 5 seconds.
Flow 2½ seconds	...	Pause 5 seconds.

In both cases the groups of bubbles were composed of individual bubbles of different sizes. Suspecting that this might be a surface tension phenomenon, the nozzle was watched and it was found that when the flow ceased water did not run back up the air tube but stopped sharply at the opening, as if a flat closing diaphragm were put over the nozzle, evidently a surface film. Before flow commenced, this was gradually blown out, and when it broke, a group of bubbles was emitted. All the bubbles in a group varied from about ½ in. to ¼ in. diameter, and all oscillated regularly as they rose. By controlling the air supply with a clip on the air delivery tube, the pulsations referred to above ceased, and single bubbles could be emitted at will. For example, in experiment 2, the bubbles were emitted at a rate of 1 per second, and were all about ¼ in. diameter, oscillating regularly from side to side as they rose, with a period of about ½ second. On looking down the tube from above it was observed that the bubbles rose in a spiral path, sometimes left-handed and sometimes right-handed, the diameter of the spiral being about twice that of the bubble. The velocity was 0·775 f.s. As the rate of flow of air increased a more rapid stream of bubbles was emitted, and they were of larger diameter. (see experiment No. 3). The bubbles tended to group themselves as they rose, so that there would be four or five groups of bubbles within the length of the glass tube, the spaces between the groups having bubbles more thinly scattered through the water. In experiment No. 3 it was not possible to time single bubbles, but group velocities were timed, and these averaged 1 f.s. Clearly the grouping is an effect arising from the wakes of the bubbles. If two bubbles are moving up together, but one behind the other, the one in the rear will tend to overtake the one ahead, provided it is not too far away to feel the effect of the wake. In such groups there is a great disturbance and darting about of the bubbles, as a bubble is sometimes in the dead water, which is probably dragged behind a preceding one, and sometimes in the displacement stream passing the sides of the leading bubbles. Groups of bubbles so formed would naturally lead to a pulsation in the delivery of the water from the top of an air lift pump, as will be referred to later. It is not so easy to see why groups should form at regular intervals up the tube. When a large volume of air was suddenly emitted into the water a single large bubble, completely filling the tube was formed, and this progressed slowly towards the surface, taking the form of a cylinder with a hemispherical upper surface, the lower surface being flat. This bubble, practically filling the bore of the tube, when large enough to become cylindrical, showed a regular corrugation on the sides, due to a series of rings. These were really ripples, caused no doubt by the rapid flow of displaced water in the small space between the bubble and the wall of the tube. The velocity of rise of such bubbles when just filling a 2-in. tube was 0·8 f.s. A similar bubble in a ¾-in. tube rose at a much lower velocity, that is, 0·5 f.s. When the air emitted was just of sufficient quantity a perfect hemisphere was formed which travelled up the tube with the flat side downwards, and as the water flowed past the space between the tube walls and the bubble, a fringe of smaller bubbles was constantly torn off the edge, so that in appearance such a bubble looked somewhat like a jellyfish. When the quantity of air suddenly emitted was not sufficient completely to fill the tube and form a hemisphere, a large bubble of irregular shape was formed, which, as it rose through the water, was constantly being torn in pieces, and re-formed.

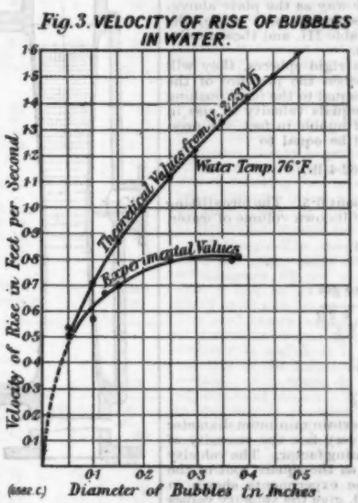
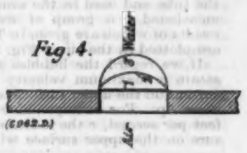
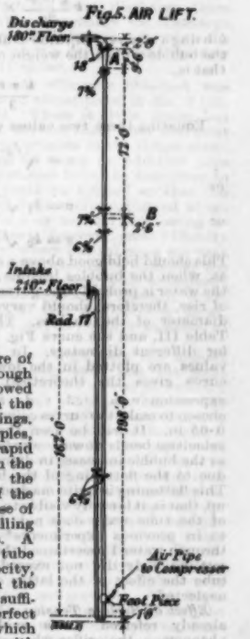


Fig. 3. VELOCITY OF RISE OF BUBBLES IN WATER.
Velocity of Rise in Feet per Second
Diameter of Bubbles in Inches
Theoretical Values from V = 2·23√D
Water Temp. 76° F.
Experimental Values
(6982.C)





The size of the bubble formed appeared to depend practically entirely upon the rate of flow of air, but there was a minimum diameter which it was very difficult to get below. For example, with No. 1 nozzle, with a diameter of 0·034, the smallest bubble obtainable was about $\frac{1}{32}$ in. in diameter, although it was noticeable that at very slow rates of flow there were occasionally emitted bubbles of about ¼ in. diameter, mixed with the others, which were all of uniform size. The largest bubbles which could be timed from No. 1 nozzle, were about ¼ in. diameter, but when the rate of flow was sufficiently rapid these coalesced into groups containing bubbles up to 1 in. in diameter. (See experiment No. 10.) This coalescence was accompanied by a continuous breaking-up of the larger bubbles into smaller ones, and a great noise and disturbance in the water. It was soon noticed that all the bubbles within the limits examined rose at almost the same velocity, that is, something under 1 ft. per second, and this was a cause of some surprise until it was observed that each bubble on its way up the tube lost its spherical shape and became flattened out horizontally. It has usually been assumed that the rate of rise of air bubbles through

TABLE III.—*Relation of Bubble Diameter to Velocity of Rise.*

(Water temperature, 76 deg. F.)

No.	Nozzle Diameter.	Bubble Diameter. (Approx.)	Velocity of Rise.	—
	in.	in.	f.s.	
1	0·012	0·05	0·53	Perforated plate used to measure diameter of bubbles.
2	0·012	0·10	0·57	,, ,,
3	0·136	0·125	0·67	,, ,,
4	0·136	0·15	0·70	,, ,,
5	0·012	0·25	0·80	,, ,,
6	0·375	0·37	0·80	Wire loop used to measure diameter of bubbles.
7	0·375	0·38	0·81	

water obeys the same law as the rate of rise of spheres of lighter specific gravity than water. If this were the case, the velocity of rise would be a function of the diameter. It appears, however, that between the force due to the bubble's own buoyancy and that due to the impact of the current caused by its movement through the water, the bubbles get flattened out, and the smaller bubbles, being more rigid than the larger, suffer less flattening. The effect of this appears just to balance the effect of size within the limits experimented with, which cover the largest diameter of bubbles, which are, or, rather, should be, formed in air-lift pumps. Doubtless here, again, surface tension is one of the governing factors and the observation would probably not hold good when the bubbles exceeded a certain diameter. In Table I, the values given for the bubble diameters are only very approximate, hence the results, as regards velocity of rise, are only to be considered approximate also. The chief difficulty in these experiments consisted in measuring the diameter of the bubbles, and in order to relate diameter with the velocity of rise an attempt was made to get more exact diameter measurements by means of a perforated plate with holes of different diameters. This was hung in the top of the experimental tube so that bubbles passing this plate could be compared with the holes in size, and thus a fairly accurate idea of the diameter obtained. In some cases the diameter was measured by a wire ring pushed into the upper part of the tube and used in the same way as the plate above-mentioned. A group of experiments was made, the results of which are given in Table III, and these results are plotted in the curve Fig. 3.

If we regard the bubbles as rigid spheres, they will attain a maximum velocity when the pressure of the current on the upper surface is equal to the force pushing them up. For example, if v equals velocity of rise in feet per second, r the radius of bubble in feet, the pressure on the upper surface will be equal to

$$k \frac{\pi r^2 v^2}{2g} \times 62{\cdot}4 \text{ lb.}$$

k being a constant of value = about 0·5. The force lifting the bubble will be the weight of its own volume of water, that is,

$$\frac{4 \pi r^3}{3}$$

Equating these two values we get :

$$v = \sqrt{\frac{4r \times 2g}{3k}}$$

or

$$v = k_1 \sqrt{r}$$

or

$$v = k_2 \sqrt{d}$$

This should hold good above a certain minimum diameter as, when the bubbles become very fine the viscosity of the water is probably the governing factor. The velocity of rise, therefore, should vary as the square root of the diameter of the bubbles. The experiments shown in Table III, and the curve Fig. 3, give the velocity values for different diameters. In Fig. 3, the experimental values are plotted in the lower curve, and the upper curve gives the theoretical values based upon the expression $v = 2{\cdot}23 \sqrt{d}$, the value of 2·23 being chosen to make the curves coincide at a bubble diameter of 0·05 in. It will be seen that the curve of measured velocities bends down towards a maximum very rapidly as the bubble increases in diameter, and this is doubtless due to the flattening of the bubbles above referred to. This flattening is quite marked from about ¼ in. diameter up, that is, it is easily visible to the naked eye. The effect of the tube walls does not, I think, account for this, as in previous experiments* on settlement of bodies through water I ascertained that when the diameter of a settling body did not exceed one-quarter that of the tube the effect of the latter on the velocity might be neglected.

Effect of Surface Tension.—The pulsating flow of air already referred to is evidently a surface-tension phenomena, the orifice when very small being closed by a surface film which opposes some resistance to the flow of air through it, which resistance is suddenly reduced when the film breaks. The effect of this, when there is a capacity behind the orifice, and the flow of air is very small, is to cause a sudden escape of the air when the film ruptures, the pressure behind the orifice being suddenly relieved. When the air has escaped the film reforms, until the pressure again rises sufficiently to cause a new flow. In Table II experiments are given which bring out this fact. They were designed chiefly to measure the excess pressure required to overcome the surface tension at the orifice.

The nozzle used is shown in Fig. 2, No. 7. This is a small inverted glass bell with a scale on the outside, having its zero at the centre of a ring of holes on the upper part of the bell. Thus, when the air is turned on, the fall of the water level inside this bell below the holes is a measure of the force required to rupture the film. Referring to Table II, it will be seen that with holes of 0·032 in. diameter, a head of 1·5 in. of water was required to rupture the film, and when ruptured the head required for a steady flow of air was reduced to 1·25 in. With larger orifices, given in the table, these values fell rapidly. The pulsating flow of the bubbles is very well demonstrated by this arrangement. When using the nozzle shown in No. 7, Fig. 2, and with a ¼-in. hole, the bubbles emitted did not fill the hole when the flow of air was very slow, but pushed out through the upper part. The flow was pulsating, groups of three bubbles being emitted at intervals of 5 seconds, the approximate diameters being ¼ in., ⅛ in. and $\frac{1}{16}$ in. Occasionally a larger number, such as five or six, were emitted, but always of graduated sizes. As the flow of air was increased, the intervals between the groups became steadily shorter, but the number of bubbles in each group remained the same. When the interval between the groups was ¼ second any further increase resulted in a continuous stream.

The cause of the variations in pressure required to force bubbles of air through a small orifice into water, arising from the surface tension, is easily understood from the following consideration. The pressure due to surface tension inside a bubble is uniform, and thus tends to produce a spherical surface. The stretching of this surface does not increase the tension, which remains constant. This results in a definite variation in pressure inside a bubble inversely as the radius. If R = radius of the bubble in centimetres, P = pressure inside a bubble above that in the water in dynes per square centimetre, S = surface tension in dynes per lineal centimetre (75·8 for water at 0 deg. C.). Then :

$$P = \frac{2S}{R}$$

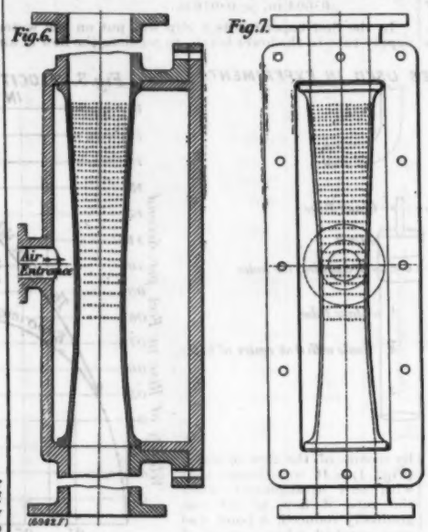
If we consider a small orifice when the pressure on the air side just balances the hydrostatic pressure on the water side, the result at this stage is that the orifice is closed by a flat film as shown at 1, Fig. 4. As the radius of the flat film is infinite the pressure on each side will be equal. When the pressure of the air is increased the film is blown outwards with a gradually increasing curvature, so that the radius is getting smaller and smaller and the pressure required to blow out the film greater, as shown at 2 Fig. 4. When the bubble forms a hemisphere with a radius equal to that of the hole, the pressure is at a maximum, the radius being a minimum, as any further blowing out will increase the radius and cause a reduction of pressure in the bubble. Thus the hemisphere is unstable, and when the bubble reaches this stage, 3, Fig. 4, it enlarges rapidly until detached from the orifice, even without further increase of pressure.

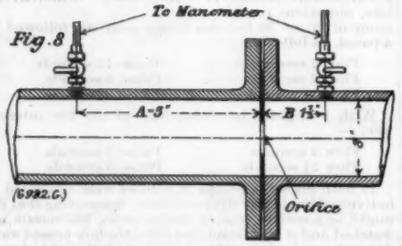
Surface tension has probably also the effect of limiting the minimum size of bubble which can be emitted in still water from an orifice of small diameter. During the pulsating flow of air when a group was emitted the bubbles usually consisted of graduated sizes, evidently owing to the falling-off of pressure and flow as the air escaped. It was found impossible to get bubbles regularly of less than about $\frac{1}{16}$ in. diameter, although the orifice used was 0·012 in. diameter. As a rule it was impossible to obtain any continuous flow of bubbles from this orifice, that is, the flow was always pulsating or in groups, but in one instance the flow consisted of a continuous stream of very fine bubbles emitting a musical note, but this altered after a minute or so to the usual pulsating flow. It would seem that, speaking generally, the size of the orifice is one of the factors governing the minimum diameter of bubble which can be produced, and it is probable that, if the surface tension effect were eliminated, bubbles of any required diameter could be emitted by adjusting the flow of air.

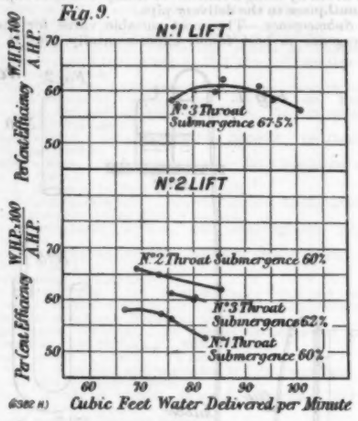
Oscillation of Bubbles.—To find if the oscillation of the bubbles was due to the flattening, a ball of paraffin wax was made, ¼ in. in diameter, and allowed to rise through the water. There was little or no oscillation. A similar ball, $\frac{1}{16}$ in. diameter, oscillated very little, but the velocity of rise was in both cases very slow. In the case of the smaller ball the velocity of rise was 0·4 f.s. (the exact diameter was 0·305 in.), so that the slow rate of rise probably accounted for the absence of oscillation. It would seem that much energy must be lost by this oscillation of the bubbles which is doubtless caused by the throwing off of eddies. All bubbles oscillated rapidly, the rate being greater as the diameter was reduced, until a value of about $\frac{1}{16}$ in. was reached at which no oscillation could be detected. These bubbles rose at the rate of 0·4 f.s., the water temperature being 76 deg. F.

C. Air-Lift Mine Pump.

This pump was designed for lifting acid mine liquors out of the mines of San Domingos, Portugal. The installation is in two lifts, each as illustrated in Fig. 5. The bottom lift, No. 2, raises the water from the 210-m. to the 180-m. floor, where the discharge from lift No. 2 is received in a large tank, or pool, which pool forms the inlet to lift No. 1. The latter raises the water from the 180 m. to the 150-m. floor.







There is no submerged pipe such as is used in tube wells, but the inlet pipe is carried down a shaft in the form of a U-tube, the air admission footpiece being fixed a little above the bend at the bottom of the U on the eduction pipe (see Fig. 5). This has the same effect as submergence, although there is naturally more friction in the present pump owing to the water having to travel down the descending leg of the U. All pipes were lined with lead, and the air pipe was made of lead, since the liquor is of a very corrosive nature, and rapidly attacks cast-iron. The first of the lifts above referred to, that is No. 2, was put in early in 1920, as an experiment, with the intention of completing the installation by adding the No. 1 lift if it proved a success. The result of the tests made after installation showed an efficiency of over 60 per cent. for the experimental pump, and this was considered to justify adding the second lift. The advantages of the air lift over other methods of pumping for this type of work are very obvious, provided a reasonably good efficiency can be obtained. There need be no machinery underground, nor need any machinery be exposed to the acid liquors. The amount of attention and repairs required for an air lift are negligible as compared with other pumps, such as, for example, ram pumps. In the case described, a three-throw electric-driven ram pump was displaced by the air lift. The electric pump was a continual source of trouble, and required great attention to keep in order, as pump and motor had to be fixed in a chamber in the mine, and were constantly exposed to drips of acid liquor.

Design of Pump.—In designing this pump the main objects aimed at were :—

(*a*) To provide a smooth unobstructed flow of water through the pipes, avoiding any method of introducing air which interfered with this object.

(*b*) To keep the bubbles of air in the eduction pipe as small as possible.

(*c*) By the use of a Venturi throat at the air-admission footpiece to arrange for uniformity of pressure at the top and bottom of the throat-piece, so that the air-distribution could be controlled.

(*d*) To avoid a sudden increase of velocity at the foot-piece, and to bring about the necessary change of velocity in the water, resulting from the admission of air, as gradually as possible.

The footpiece is illustrated in Figs. 6 and 7, from which it will be seen that the air is admitted into an annular chamber surrounding a Venturi throat-piece, the latter being perforated with a number of holes of ⅛ in. diameter, starting from the narrowest part of the throat. In determining the length of this throat-piece this was fixed so that the angle of opening of the trumpet-shaped upper part should not exceed 5 deg. The diameter at the throat was made such that the loss of head due to velocity at the throat would somewhat more than balance the static head due to the increased depth at the throat. The object of this was to cause the air admitted into the annular space to flow through the holes in the throat-piece with uniform pressure from top to bottom, and thus the amount of air admitted at any section would be in proportion to the number of holes in that section. The holes were distributed in rings around the throat-piece,

* R.G.S. Research Dep., 1908.

the number per ring gradually increasing towards the top so that as the air was added to the water, and the velocity thereby increased, the rate of increase would be such that the velocity head would vary uniformly. In some cases the holes were distributed in a spiral on the throat-piece, to permit of more gradual increase in the volume of air admitted. From 550 to 600 holes were used.

The footpiece was of cast-iron lead-lined and designed to simplify the changing of the throat-piece, so that different forms could be experimented with. A number of tests were made, and the results of these are shown in Tables IV and V. The supply of compressed air for these pumps was from the air-line supplying the mine, and no special compressor was required. The air was at 80 lb. per square inch, and this determined the maximum submergence possible. In making the tests, the volume of air used was measured by means of an orifice fixed in a 3-in. air line. This orifice was supplied by Messrs. Kent, and is illustrated in Fig. 8. It was especially calibrated, and the formula for calculating the volume of air was obtained as follows: A differential manometer was arranged to measure the difference in pressure at each side of the orifice.

TABLE IV.—TESTS OF AIR LIFT NO. 1 UNDER DIFFERENT CONDITIONS.

Test No.	1	2	3	4	5	6	7	8	9	10
Dip, or submergence, in feet	202	202	202	202	202	202	202	200	200	202
Lift, in feet	97·0	97·0	97·0	97·0	97·0	97·0	98·0	99·5	99·5	98·0
Submergence per cent., *i.e.*— submergence × 100 / lift + submergence	67·5	67·5	67·5	67·5	67·5	67·5	67·5	67·0	67·0	67·5
Delivery pipe, inches	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½
Air pipe, inches	3	3	3	3	3	3	3	3	3	3
Water raised per minute, tons	2·38	2·15	2·62	2·69	2·85	2·43	2·60	2·47	2·80	2·65
Water raised per minute, cub. ft.	84·4	76·0	92·8	95·2	101·0	86·2	96·3	87·4	99·0	93·8
Volume of free air used per minute in cub. ft.	224	206	242	259	287	219	261	224	256	240
Volume of free air used in cub. ft. per cub. ft. of water raised	2·66	2·68	2·61	2·62	2·84	2·65	2·71	2·57	2·89	2·56
Water horse power	16·7	15·06	18·34	18·84	19·06	17·06	19·01	17·74	20·10	18·68
Air horse-power	28·82	25·80	30·06	32·17	35·30	27·37	32·57	27·66	34·92	29·64
Efficiency	60·00	58·40	61·00	58·57	56·60	62·33	57·37	64·13	57·56	63·03
Throat-piece No.	3	3	3	3	3	3	2	2	2	2
	3·9 in. diameter									
Discharge	Slight pulsation	Slight pulsation	Steady	Steady	—	—	Steady	Slight pulsation	—	Pulsating

TABLE V.—TESTS OF AIR LIFT NO. 2 UNDER DIFFERENT CONDITIONS.

Test No.	1	2	3	4	5	6	7	8	9	10
Dip, or submergence, in feet	156·0	156·0	156·0	156·0	156·0	156·0	156·0	158·5	158·5	158·5
Lift, in feet	105·0	105·0	105·0	105·0	105·0	105·0	105·0	97·7	97·7	97·7
Submergence per cent., *i.e.*— submergence × 100 / lift + submergence	60	60	60	60	60	60	60	62	62	62
Delivery pipe, inches	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½
Air pipe, inches	3	3	3	3	3	3	3	3	3	3
Water raised per minute, tons	2·15	2·09	1·90	2·34	2·42	2·08	1·96	2·27	2·26	2·15
Water raised per minute, cub. ft.	76·0	74·0	67·0	82·5	85·4	73·4	69·2	80·4	80·0	76·0
Volume of free air used per minute in cub. ft.	253	244	218	290	254	209	199	238	238	222
Volume of free air used in cub. ft. per cub. ft. of water raised	3·33	3·30	3·23	3·50	3·00	2·85	2·88	2·96	2·98	2·92
Water horse-power	16·2	15·8	14·35	17·62	18·20	15·70	14·80	16·04	15·99	15·19
Air horse-power	28·8	27·7	24·8	33·6	29·4	24·2	22·4	26·63	26·63	24·84
Efficiency	56·3	57·1	57·9	52·5	62·0	64·9	66·1	60·23	60·05	61·16
Throat-piece No.	1	1	1	1	2	2	2	3	3	3
	4·59 in. diam.				3·25 in. diam.			3·9 in. diam.		

Calling h = manometer reading in inches of water.
p = pressure on up-stream side of orifice in pounds per square inch absolute.
T = temperature at orifice in F deg. absolute.
A = The quantity of air in cubic feet free air per minute.

Then

$$A = 211{\cdot}7 \sqrt{\frac{h\,p}{T}}$$

The discharge of the water was measured by means of a rectangular weir, 18 in. wide, using Francis' formula, that is:—

Calling W, cubic feet water per second.
L, width in feet.
H, head in feet.
n, number of end contractions = 2.

Then

$$W = 3{\cdot}33 \left(L - \frac{n}{10} H\right) H^{\frac{3}{2}}$$

or for this weir,

$$W = 3{\cdot}33 \left(1{\cdot}5 - \frac{H}{5}\right) H^{\frac{3}{2}}$$

Great care was taken that there should be plenty of time for the air to separate from the water before it reached the weir, and that the width and depth of the channel of approach to the weir should be adequate.

From the results of the tests set forth in Tables IV and V, it will be seen that the efficiency of the No. 1, or upper, lift, varied between 56·6 per cent. and 64·13 per cent., while the efficiency of the No. 2, or lower, lift, varied between 52·5 per cent. and 66·1 per cent. The conditions under which the tests were made were varied with the object of ascertaining the best form of throat-piece, hence tests are shown with three different throat-pieces, varying in diameter at the throat between 3·25 in. and 4·59 in. It is evident from the table that the throat-piece with the smallest diameter gave the highest efficiency. A further pair of throat pieces are now being experimented with in which the diameter of the narrowest part is 2½ in. It will be observed from Fig. 5 that the discharge ends of the eduction pipes are enlarged by a taper piece up to 18 in. diameter, in order to minimise the loss in kinetic energy of the water. In some of the tests the foot-piece was fixed so that the centre of the air inlet pipe was 3 ft. above the top of the bend in the water pipe, but this was found insufficient, as there was a great tendency for the air to blow back round the bend and momentarily reverse the action of the pump. The footpiece, therefore, was lifted to a height of 12 ft. above the bend, and this was found effective in preventing such blow-backs.

Starting of Pump.—On turning on the air to the pumps they invariably commenced by an almost explosive discharge of air and water, which occurred a few minutes after the air had been admitted. After this had occurred the flow usually settled down to a steady stream. This method of starting appears to be almost an essential under the conditions, as the following consideration shows. The operation of starting may be divided into certain stages, as follows:—

1. Compressed air is admitted to air pipe until head of water is just balanced; the air pipe is then full of air to footpiece, but no air has yet entered rising main.

2. The water in rising main is at rest, *i.e.*, there is no flow past footpiece. Air is admitted to rising main, but as there is no water current to carry it away, probably collects in large plugs, or one large plug above footpiece, displacing the water until the latter reaches the top and overflows.

3. When the water overflows at the top the pressure on the column of air is relieved, and it expands, causing a greater overflow, and if the plug of air is at the bottom of the rising main, or anywhere well below the top, as the column of water is removed it tends to expand with explosive violence, since its own expansion relieves the pressure and the relief of pressure causes expansion.

4. The relief of pressure on the rising main is so rapid that it cannot be compensated for by flow in at the bottom, and therefore the pressure in air pipe will fall, to recover gradually as the rising main fills from below.

5. It is during stage 4, when water is flowing past the footpiece that the air has a chance of mixing with the water and, if enough air is admitted then, continuous flow will result. If, however, insufficient air is admitted, it may be sufficient only to keep the water near the level of delivery without overflowing, *i.e.*, supposing the quantity admitted is equal to the quantity which can slip through the water and escape from the top as bubbles, in this case no water will be delivered.

Pulsating Flow.—The flow from the lifts was sometimes continuous and steady, while at others it was irregular and pulsating with varying degrees of intensity, from a mere variation in flow which was just observable, to intervals of complete stoppage. It may be that the pulsating flow of air due to surface tension, which has been referred to in the earlier part of this paper, is one of the causes, when the air admission holes are very small. It may be, also, that the bubbles are grouping in the eduction pipe at regular intervals, and when the air flow permits of such grouping its effect would be to cause a pulsation in the delivery.

It was observed that in the tests of the mine lifts, when the air supply was gradually reduced, a point was reached when the pump action instead of being steady became uncertain, with irregular pulsating flow. It is suggested that the cause of this may be somewhat as follows, remembering that the air mains were supplying rock drills and other plant as well as the lifts: Suppose the lift is working steadily without pulsation and the air pressure is constant. The velocity past the foot-piece will have reached a steady value, say, equal to V. Now, suppose the pressure of the air supply rises a little, the result will be that more air is blown in through the footpiece; but this increased quantity will be blown into the water flowing past at a velocity equal to V, corresponding with the original pressure. This velocity will not alter except as a result of the increased air supply, and therefore the alteration of velocity to, say, V_2, must follow in point of time the increase of air. Thus there will be a lag, and if the air supply is suddenly increased there will be an interval of time before the velocity of the water is increased to V_2. During this interval of acceleration the water will receive more air than corresponds to its average velocity, and therefore, when the velocity corresponding to its increased air supply has been reached, that is V_2, it will find the mixture in the rising main more highly charged with air than it should be for that velocity. The result of this will be that the velocity will go on increasing beyond V_2 in the attempt to reach a new velocity, say, V_3, corresponding to the increased amount of air present. During this stage the proportion of air supplied to the water is reduced below that corresponding to the velocity V_3, and therefore the velocity will begin to fall again. Thus we have an oscillation set up in the eduction pipe, which may go on for some time before it dies down. It is curious to observe that in nearly all the tests the highest efficiency was obtained with a pulsating flow. There is also to be observed a delivery of maximum efficiency. The curves shown in Fig. 9 give the efficiencies plotted over discharge for different throat-pieces, with different submergences, and although it does not appear from all these curves that there is a discharge of maximum efficiency, it may be pointed out that when the maximum efficiency was obtained with the lowest discharge, there was a limiting factor which prevented the discharge being reduced below a certain value, that is, when the air supply was cut down below a certain point the flow of the pump became too irregular.

Efficiency.—The maximum efficiency obtained was 66·1 per cent., using No. 2 throat-piece in No. 2 lift, submergence 60 per cent. There is little doubt but that it can be increased beyond this; and the most likely means to adopt is a variation in the throat-piece. The well-known expedient of using an eduction pipe of gradually increasing diameter from the foot-piece to delivery is useful, if it could be applied so that the velocity of the mixture is kept uniform, instead of increasing as it must do in a cylindrical pipe owing to expansion of the air. There is, however, great difficulty in applying it practically, where conical pipes are very costly, and instead of a gradual change in diameter the enlargement is usually made in steps, with consequent loss at each step. It seems doubtful if there is much advantage to be gained in this way over a short, trumpet-shaped, or conical delivery end with sides at 5 deg. or less.

The fact that the smallest throat gave the highest efficiency is curious. It is suggested that the most probable explanation is in the effect on size of bubbles. The rate of flow of air through each ½-in. hole in the pump footpiece was about 0·44 cub. ft. per minute. The greatest flow used in a single orifice in the experiments described in the earlier part of the paper was 0·0465 cub. ft. per minute, or about one-tenth of that in the pump. There was great disturbance even with this, and bubbles about 1 in. diameter formed by coalescence. The only forces limiting the size of bubbles here were the floating power of the bubbles, surface tension and the water pressure, which make a cylinder of air in water unstable and tend to break it up into spheres. In the case of the pump there is another very powerful factor, that is the flow of water past the holes, which sweeps away the bubbles before they can grow big. The faster the flow of water the greater the force exerted and the smaller will be the bubbles emitted from any given hole. This appears to be the reason for the higher efficiency with the smaller throat. The smallest yet tried had a diameter of 3½ in., and this is being reduced to 2½ in. to ascertain whether further improvement will result.

It seems advisable also from this point of view, to admit the air where the velocity is highest, *i.e.*, at the narrowest part of the throat, and this is being tried now, but it is questionable whether other drawbacks will not neutralise any advantage to be gained thus.

SAFEGUARDING OF INDUSTRIES ACT.—In accordance with section 7 of the Safeguarding of Industries Act, the President of the Board of Trade has appointed the following gentlemen to be members of the permanent panel from which committees, consisting of five persons, will be selected from time to time to consider and report upon complaints referred to them by the board under Part II (Prevention of Dumping) of the Act: Sir W. M. Acworth, Mr. J. Arthur Aiton, C.B.E., Sir William Ashley, Mr. Arthur Balfour, J.P., Sir George S. Barnes, K.C.B., K.C.S.I., Sir John N. Barran, Bt., Mr. J. T. Brownlie, Sir Cecil L. Budd, K.B.E., Sir James C. Calder, C.B.E., Dr. J. H. Clapham, C.B.E., Mr. T. P. Cook, Mr. F. R. Davenport, Mr. A. K. Davies, Mr. F. P. Dorizzi, Mr. Rayner Goddard, Sir E. C. K. Gonner, K.B.E., Sir George R. Lowndes, K.C.S.I., K.C., Professor D. H. Macgregor, Mr. Stanley Machin, J.P., Mr. G. A. Moore, Mr. J. W. Murray, D.L., Sir Douglas Newton, K.B.E., Mr. Owen Parker, C.B.E., J.P., Mr. R. G. Perry, C.B.E., Mr. Arthur Pugh, Sir R. Henry Rew, K.C.B., Mr. C. A. Russell, K.C., Mr. Arthur Shaw, Sir Charles Stewart, K.B.E., Sir Edwin F. Stockton, J.P., Mr. H. L. Symonds, Mr. Gilbert C. Vyle, Sir Frank Warner, K.B.E.

NOTE ON THE PROPOSED MID-SCOTLAND SHIP CANAL.*

By D. A. STEVENSON, B.Sc., F.R.S.E., M.Inst.C.E.

I HAVE been asked by the Executive to open the discussion on the subject of the formation of a ship canal between the Forth and the Clyde. I think I may claim to speak with some authority on the subject, as I have devoted a great amount of time to the study of the question.

In 1889, now 32 years ago, a committee of gentlemen asked my firm to consider and report on the feasibility of forming a ship canal on the line of the existing barge canal. We carefully considered the project and reported that, in our opinion, a satisfactory ship canal could not be constructed on that line, and recommended the adoption of a route up the valley of the Forth through Loch Lomond and down Loch Long. The committee approved of the report, but failed to make any progress with the scheme. Since that time I have read papers on the subject before various learned and unlearned societies advocating the Loch Lomond route. During this period four financial houses from time to time approached us on the subject, but found themselves unable to tackle such a large undertaking. In 1906, and again in 1909, I gave evidence before the Royal Commission on Canals, and in 1909, at the invitation of the Committee of Defence, I appeared before it and described the scheme in full detail.

Meanwhile, we had brought the subject before the late Sir John Jackson, the well-known contractor. He entered eagerly into the matter, and in concert with several of his friends, among whom were the late Lord Strathcona and the late Duke of Sutherland, resolved to promote a Bill in Parliament to carry out the scheme. We accordingly surveyed the route and prepared the necessary plans and estimates, but at the last moment it was considered inadvisable to proceed without some indication that the Government would at least approve, if not support financially, such a scheme, and this was not obtainable at the time. Since then, however, the report of the Royal Commission on Canals has been issued, and in it it is stated that the Government might assist financially a ship canal scheme, provided it were constructed on the Loch Lomond route, the route proposed and advocated by my firm. The Commission had our proposed scheme before it in detail when it came to this decision.

There can be no doubt that from an engineering point of view the weight of evidence is in favour of that route. In addition to our own views, this route had the approval of the late Sir Edward Leader Williams, the engineer of the Manchester Ship Canal, and of the late Sir John Fowler, both of whom looked into and approved of our plans, and also of the late Sir John Jackson, who thoroughly studied the subject with us.

Our scheme, as is well known, is that vessels should proceed up the Forth to a point just above Grangemouth, then by means of one or two locks, depending on the state of the tide, rise to the level of Loch Lomond, which is only 22 ft. above the mean level of the sea, pass right through on that level to Arrochar on Loch Long, and at that place drop down to sea level again. The distance from the Forth, just above Rosyth, to the Cloch Lighthouse in the Firth of Clyde, would be 63 nautical miles, of which 30 miles would be in open water. The deepest cuttings would be 191 ft. at a point south of Stirling, 285 ft. at the head of the Forth valley, and 142 ft. between Tarbet and Arrochar, but these are maximum depths and extend over only very short distances, the average depth of cutting being 101 ft. The depth of the proposed canal that has been in view up to the present time is 36 ft. with a width at bottom of 148 ft. At spring tides the lift at the Forth end would be 13 ft. at high water, 31 ft. at low water; at Arrochar 17 ft. and 27 ft. respectively. There are no railway swing bridges on the route and only seven road swing bridges, the three railways and the other roads being carried over the canal by fixed bridges with a headway of 120 ft. The sharpest curve has a radius of 2 miles. The water courses that are crossed are few in number and small, and can easily be taken across the canal by syphons. There would be some 170,000,000 cub. yards of material to excavate and dispose of, some portion of which would be utilised in constructing the works; the remainder would be deposited in the deep parts of Loch Long and Loch Lomond, on the waste land in the vicinity of the canal, such as Flanders Moss, and on the slob lands in the Firth of Forth, near Grangemouth.

The borings that we have made on the line of the proposed route are very favourable; the foundations for the locks at the Forth end would, however, be deep, as the formation is alluvial sands and clays, and, speaking generally, shale, sandstones and clay will be encountered between the Forth and Bannockburn; basalt and sandstone will be met in passing Stirling; alluvial sands and clays in the low ground of the Forth valley; sandstones in the haunch of Ben Lomond; gravels are met in the Endrick valley. The cutting between Tarbet and Arrochar is in schist, and will afford a good foundation for the locks at the latter place. A large portion of the cutting, especially where it is deepest, is in rock or hard material—a fortunate circumstance, as, when a cutting exceeds about 80 ft. in depth, it is cheaper to form the cutting in rock than in soft material.

Our estimate for the work, if carried out, to the dimensions necessary to suit the requirements of the Defence Committee was, at pre-war rates, 24,400,000*l.*, while a canal that would suit commercial purposes, 70 ft. wide in the bottom and 31 ft. deep, would cost 12,200,000*l.* It is not possible to form a reliable estimate of what the work would cost if undertaken during the next few years owing to the uncertain state of the labour and other markets. The canal, we estimate, would take seven years to complete.

I do not propose to deal fully with the objections to the so-called "direct" route, viz., on the line of the present barge canal. Advocacy of that route was started as an opposition scheme by the late Mr. Law Crawford, subsequent to the appearance of our Loch Lomond scheme. No doubt it is in distance some 16½ miles shorter from Rosyth to the Clooch, but it is practically all in canal or dredged channel where large vessels could not proceed at full speed, while a total length of 30 miles of the Loch Lomond route is in open water. This, and the fact that a considerable number of railway and road swing bridges would be required on this route, which hold up traffic, renders the Loch Lomond route in reality the shorter as regards time, and this is the important consideration. The cutting on this line is also to a large extent in soft ground, rendering the excavation, which is deep, very wide and expensive. If there were no other objections to this route, it is condemned by the fact that where the canal joins the Clyde between Clydebank and Dumbarton it will be necessary to carry both the road and the railway at that point by swing bridges across the canal, causing serious interruption to the traffic not only on the canal, but also on the roadway with its important tramway lines, and on the railway. Still more objectionable—and this from a navigation point of view—would be the difficulties and dangers to which vessels would be subjected in entering and leaving the Clyde and mingling with the up-and-down traffic to and from Glasgow. Lastly, the idea of forming a canal at sea level on this "direct" route is out of the question as, on account of the rise and fall of the tide, locks are absolutely essential at each end, and, if it is necessary for a vessel to enter a lock, it is not a matter of moment whether she is raised 10 ft. or 30 ft. The construction, too, of a canal at such a low level would introduce great engineering difficulties and enormous expense.

As to the advantages that a ship canal between the Forth and Clyde would confer on commerce, it is not necessary to enlarge. Water carriage is the cheapest form of transport for heavy goods and for all goods in large quantities. If practical proof of this were wanted, we have only to consider what has been spent by Glasgow in deepening the Clyde, and by Manchester in forming her Ship Canal to bring shipping up to their doors. The Forth and Clyde Ship Canal will enable vessels proceeding from ports on the west side of the country to ports on the east side, and *vice versa* to save on each voyage from 100 miles to 500 miles of steaming, the actual amount depending on the relative position on the coasts of the ports they are bound from and to. There is a very large coasting trade which passes round the North of Scotland which would reap the benefit of the canal. My firm has from time to time made several careful estimates of the amount of existing traffic that would use the canal and also of the dues that might be collected, with the result that I feel satisfied that a moderate return on the capital expended on the work would be obtainable. Government alone, however, can call for and obtain the necessary returns on which a really correct estimate can be formed, as no statistics are available to the public which would enable us to make allowance for the ordinary growth of traffic, for the large development of new traffic which the canal would, without doubt, looking to the history of such undertakings, create and foster, and for the traffic between the Continent and America, a large portion of which would also use the canal. In estimating the dues that could be collected, it must be kept in view that the total saving effected is not merely in the amount saved by a vessel having to perform less steaming and thereby saving coal, oil and wages, but also in the saving effected in insurance, in wear and tear of hull and machinery, giving the ship a longer life. It is especially to be noted that there will also be an increase in the earning power of a ship in that she will be able to make more voyages in a given period.

I would refer those who are interested in this aspect of the subject to the evidence and tables I laid before the Royal Commission on Canals, which are printed in Vol. V., Minutes of Evidence, accompanying that Commission's Report.

I may say here that it is a mistake to suppose that the shipowner will be the class who would principally benefit by the canal; it is the manufacturer, the general trader and the public generally who will reap the principal benefit by having goods transported at lower rates.

The supineness of public opinion shown hitherto on the subject is what surprises many people, but it is easily accounted for. Members of the general public quite naturally take up the idea that if the scheme will confer such benefits on general trade as is alleged, it would be eagerly taken up and pushed by such places as Glasgow, Leith, and other places deeply interested in shipping, and as these ports have not, so far, taken the matter up enthusiastically, it is concluded there can be little or nothing of practical benefit in the scheme. The attitude of these ports is, however, easily explained. The scheme is not of such paramount importance for any one port, or even for any group of ports, as is its own individual harbour approach. The scheme is a through-route one by which all business centres, and the country generally, will benefit, and hence it is not felt to be the individual business of any of these ports.

As to the strategical advantages of the canal, the Imperial Defence Committee, as stated by the Canal Commission, considered it would possess some strategical value. Nevertheless, the work was not proceeded with before the Great War, when it would have proved of the greatest value to this country. Perhaps in this connection I may quote what I wrote on this in 1910:—

"As to the advantage to the country that the canal would be as a strategical asset in time of war, it requires only common-sense to realise that such a canal as is proposed would be of great assistance in the defence of the country. The canal would provide another door—not a mere back-door—to Rosyth, by which vessels damaged in what we are told will probably be the theatre of operations—viz., the North Sea—can proceed to the Clyde, Barrow, and Belfast, or even Plymouth or Portsmouth, for repair, and return without having to run the gauntlet of hostile vessels patrolling the approaches to the English Channel or the Pentland Firth. It would enable a fleet, watched or blockaded by an enemy in the Forth, to be withdrawn, so as to operate elsewhere or be strengthened by reinforcements, and this without the knowledge of the enemy; it would give us a great power of deceiving the enemy as to where our vessels were concentrating in force, and of quickly altering that point if desired, screened from the knowledge and observation of the hostile fleet. Loch Lomond and the canal itself would furnish a harbourage for vessels out of gun-fire and out of the exposure to torpedo attack—a point in which our naval harbours are one and all lamentably deficient, an exposure which in times of stress, and when waiting for the time for action to arrive, I am told, and can well believe, has not unnaturally a bad effect on the nerves and fitness of those who man our ships."

Perhaps I may be allowed to say a word on a statement that appeared in the Press on the 7th inst. The statement was made at a meeting in Glasgow that the Secretary for Scotland had intimated that the Admiralty had stated that, although the Loch Lomond route has from a naval aspect many advantages over the direct route, they realised the latter was the only route which might possibly be a commercial success.

It is not easy to see how the latter part of this opinion can have been arrived at. The reverse is, in my view, the case, and probably after further consideration their Lordships may change their opinion. In the first place the direct route canal will cost some 50 per cent. more to construct; it will cost more to maintain as so much of the cutting is in soft material, the ordinary working of the traffic on it will also cost more on account of the large number of swing bridges on the route, the burden of rates on the undertaking will also be heavier, while all vessels using the canal will be chargeable with rates for the maintenance of the Clyde channel. Perhaps their Lordships may have fallen into the mistake of imagining that the direct route would pass through country which is already the centre of large manufacturing and mining enterprises, while the Loch Lomond route does not do so, and that the existing route would tap a traffic which would be very remunerative. This may seem very plausible, but as a matter of fact there are practically no works on the route of the present barge canal, except in the immediate neighbourhood of Falkirk and Maryhill, and even if there were, this part of the country is already opened up and well served by the existing railways. No part of the district is more than 20 miles by railway from a shipping port, and no one would contemplate making the canal from end to end a shipping port in addition to being a canal. To do that, the canal would require to be doubled or trebled in width, and the expense of making it, therefore, would likewise be nearly doubled or trebled. Further, it is only those works through whose land the canal was actually cut who could use it in such a way, as those which did not lie immediately on the canal banks would still have to put their goods on rails to take them to the canal, and might then as well run them, as they do at present, to existing shipping ports. If such a scheme were given effect to and goods were actually shipped in the canal, the Clyde and Forth ports would then really have some good ground for grumbling at the loss of traffic in their harbours. The contrary view would indeed seem to be the best for the country generally, viz., to open up the country on the Loch Lomond route, though that is only a very secondary consideration, because it is a through route that is aimed at.

* Paper read before Section G of the British Association, at Edinburgh, September 12, 1921.

AERIAL MAIL ROUTE BETWEEN STOCKHOLM AND REVAL.—The Swedish Aerial Traffic Company have started a regular mail route between Stockholm and Reval, comprising two trips by aeroplane per week, according to *Swedish Export*. The company is to receive 600 kr. per trip from the Swedish Government for this service, and there are reasons to expect that the Esthonian Government will come forward with a subvention for maintaining the traffic. The postage charges are the ordinary ones without additions of any kind to the regular franking.

STANDARDISATION IN SWEDEN.—We read in *Swedish Export* that as a result of a general meeting convened by the Federation of Swedish Industries in the spring of 1919 to deliberate on the question of standardisation in different lines of industry, very effective work with that end in view is being carried out in the engineering, electrical, building and paper industries of Sweden. The standardisation bureau of the Swedish engineering works has already been able to fix a number of standards, especially in regard to screw thread systems and bolts, and a great many more are in the process of being worked out and adopted. The bureau is working in co-operation with most of the standardising organisations of other countries, as, for example, those of Belgium, Canada, France, Germany, Holland, Switzerland and the United States, and has been represented at the joint conferences arranged by those organisations. The bureau is keeping in touch with and paying close attention to the standardisation movement in the different countries that aim at the establishment of international standards of manufacturing. The Swedish electrical industry has now appointed a standardisation committee.